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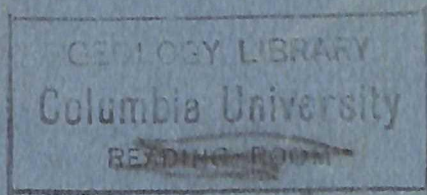
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TRIASSIC LIFE OF THE CONNECTICUT VALLEY

REVISED

By

RICHARD SWANN LULL, Ph.D., Sc.D.
Sterling Professor of Paleontology and Director of
Peabody Museum, Emeritus, Yale University



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STATE GEOLOGICAL AND NATURAL HISTORY SURVEY

EDWARD L. TROXELL, Ph.D., Director

Bulletin No. 81



HARTFORD
Printed for the State Geological and Natural History Survey
1953

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OF THE

CONNECTICUT VALLEY

BY

RICHARD SWANN LULL, Ph.D., Sc.D.

Sterling Professor of Paleontology and Director of
Peabody Museum, Emeritus, Yale University



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PREFACE TO THE FIRST EDITION

The following dissertation has been prepared in compliance with a request from Professor William North Rice, and has resulted in as exhaustive a study as possible, not only of the terrestrial vertebrates themselves, but of the environmental conditions, both physical and organic, which governed their mode of life. The field of research necessarily included the entire environmental unit, the Connecticut valley, even though the work was prepared under the auspices of the Connecticut Geological and Natural History Survey; and only serves to emphasize the necessity of similar correlated investigations of the other areas of Newark deposition.

The selected list of works given in the bibliography were all used in varying degree; but I wish especially to acknowledge my indebtedness to the Hitchcocks, father and son, to Professors Marsh of Yale, von Huene of Tübingen, Emerson of Amherst, Rice of Wesleyan, and to my colleagues, Professors Schuchert and Barrell. Miss Clara M. LeVene, librarian of the Peabody Museum, has painstakingly prepared the manuscript for the press, while Mrs. Lull has aided very materially in the preparing of the illustrations.

Acknowledgements for permission to reproduce illustrations and for the loan of electrotypes are due to the American Museum of Natural History, to the Boston Society of Natural History, and to the Peabody Museum of Yale University.

PREFACE TO THE REVISED EDITION

After an interval of some thirty-six years, it has been deemed desirable to attempt to bring up to date the writer's first edition of Bulletin No. 24 of the Connecticut Geological and Natural History Survey, to emphasize the increase in our knowledge of the probable conditions and the inhabitants of the Connecticut valley of Triassic time. The change in our conception of the climatic conditions is due to detailed studies by Paul Krynine as set forth in Bulletin Number 73 of the Survey. The classification of the animals whose bones have been found in Connecticut is based upon the findings of V. Huene, Romer, and others. Little attempt has been made to revise the invertebrate trails other than to insert the specific descriptions, but the vertebrate trackways have been carefully redescribed and more fully illustrated and reclassified zoologically as far as possible.

A novel feature is an attempt to visualize the animals which made the more understandable trackways, by means of plasteline models which have been drawn together with their trails for illustrative purposes.

It has been necessary to redraw all the figures, due to the loss of the originals, and this has been done very feelingly by Miss Shirley Glaser of the Peabody Museum staff through the courtesy of Director Dunbar. Miss Dorothy Lull has aided in the typing of such changes as have been made and in preparing the revision and seeing the completed volume through the press. Sincere thanks are also due to my various colleagues for advice and criticism, and especially to Dr. Paul Krynine; and to Dr. Edward Troxell, Director of the Survey, for his sympathetic understanding of the project and his willingness to aid in its fruition in every material way.

INTRODUCTION

One of the most interesting chapters of the earth's past history is that of the time when there were laid down the Triassic strata of the famed Connecticut valley, interesting in the profusion of its indicated life, and fascinating in the baffling obscurity which shrouds most of its former denizens, the only records of whose existence are "footprints on the sands of time."

It is not surprising, therefore, that geologists should have turned to the collecting and deciphering of such records with zeal; nor is it to be marveled at that, after the exhaustive researches of the late President Edward Hitchcock, workers should have been attracted to other more productive fields, leaving the footprints aside as relics of little moment compared with the wonderful discoveries in the great unknown west.

HISTORICAL SKETCH

Except for small summary papers by Professor Charles H. Hitchcock containing descriptions of some new species, and occasional papers by some other authors, little was done from the time of the publication of Edward Hitchcock's notable "Ichnology of New England" in 1858, and the Supplement to it in 1865, until 1904, when a new study of the tracks in the light of recent paleontology was published by the present author.¹

Skeletal remains which were brought to light from time to time were described mainly by Professor Marsh in the *American Journal of Science*, and by E. Hitchcock, Jr. (1865), and Cope (1869); and later summarized by Marsh in "Dinosaurs of North America" (1896 B).

A final, more exhaustive study of the skeletal remains was made by Professor Friedrich von Huene in his "Dinosaurier der aussereuropäischen Trias." No serious attempt, however, has ever been made to reconstruct the physical conditions of the Trias and to repopulate the Connecticut lands of that time with their living, breathing, strenuous inhabitants.

The purpose of the 1915 Bulletin, therefore, was to restore the environment, both physiographic and climatic, to clothe it with its proper vegetation and to discuss as fully as may be the animal life of that distant day.

A remarkable feature of the fossil remains of the Connecticut valley is the dearth of actual bones and the marvelous abundance of footprints—conditions the reverse of those found in other fossil fields, for, outside the Triassic of New England, New Jersey, and Pennsylvania, footprints are rarely met with, while bones in some localities are nearly as numerous as in the Valley of Dry Bones, the vision of which

¹ Lull 1904 A.

was vouchsafed to Ezekiel. Somewhat similar conditions to those in the Connecticut valley seem to prevail in the Southwest and elsewhere, but in no other known locality is the profusion of footprints so great. In spite of this, the discovery of bones in 1818 preceded a scientific appreciation of the tracks by nearly a score of years, though doubtless the latter were often seen by observers like Pliny Moody in 1802, who discovered the tracks of *Otozoum*, but failed to realize their great significance. The reference of one to the footprint of "Noah's raven" is probably only one of similar interpretations in the folklore of the Connecticut valley.

The profusion of species of animals represented by the tracks, which of course include the creatures the skeletons of which are known, seems to be as great if not greater than that of any other known vertebrate fauna of prehistoric times, and emphasizes once more the usual incompleteness of our geological record and the countless multitude of creatures which peopled our globe in the more remote ages.

PART I. THE TRIASSIC PERIOD

THE CONNECTICUT VALLEY

The rocks of the Newark system, which include the fossils under consideration, occupy a number of areas along the eastern coast of North America, of which the best-known are that of the far-famed Connecticut valley, and the adjacent one stretching from New York, through New Jersey, Pennsylvania, and Maryland into Virginia.

EXTENT OF THE TRIASSIC LOWLAND

The Connecticut valley area, extending as it does across the states of Massachusetts and Connecticut, follows in general the depression now drained by the Connecticut river, except in its lower course where the river forsakes the ancient valley at Middletown, and cuts its way through the Eastern Highland, reaching Long Island sound far to the eastward. The length of the Triassic trough is about 108 miles, from the village of Northfield, Massachusetts, on the north, to New Haven bay on the south. Its width varies, but averages 16 to 18 miles, the total area being estimated as not far from 1311 square miles.

This Triassic depression is bounded on either hand by elevations of more ancient crystalline rock none of which is younger than the Paleozoic, and the weathering of which, especially in the eastern highlands, constituted the source of the Triassic sediments.

AGE AND GEOLOGICAL HISTORY

Eastman (1913, p. 23) tells us that the best authorities have placed the Triassic rocks of eastern North America in the uppermost division of the Triassic system, that which in European geology is called the Keuper. This opinion has rested hitherto almost exclusively upon the evidence of paleobotany. He says:

"Lester F. Ward, writing in 1891, expressed the view that the flora of the New York-Virginia area fixes the horizon of the so-called 'Newark formation' with almost absolute certainty at the summit of the Triassic system, and narrows the discussion down chiefly to the verbal question whether it shall be called Rhaetic or Keuper. . . . The beds that seem to be most nearly identical, so far as the plants are concerned, are those of Lunz, in Austria, and of Neue Welt, in Switzerland. These have been placed by the best European geologists in the Upper Keuper. Our American Trias can scarcely be lower than this, and it probably cannot be higher than the Rhaetic beds of Bavaria."

After a very careful comparison of the Newark fishes with those of several European faunas, Eastman held that the fishes seem to indicate a somewhat earlier date. He said (p. 32): "This tends, there-

*GEOLOGIC SECTION OF THE TRIASSIC
OF THE CONNECTICUT VALLEY*

		FORMATION	CHARACTERISTIC FOSSILS
NEWARK GROUP	Portland arkose	Upper series of sandstones, silt-stones, shales, and local conglomerate 3,500 feet	The greatest profusion of known footprints and trails, both in-vertebrate and vertebrate <i>Anchisaurus</i> spp. <i>Yaleosaurus</i> <i>Ammosaurus</i> <i>Podokesaurus</i> <i>Stegomosuchus</i> } Skeletons
	Meriden formation	Upper Trap Sheet, 50 to 150 feet	
		Upper (Posterior) shales, etc. 1,200 feet	Dinosaur tracks. First presumably plant-feeding dinosaur Plants and fishes in black shales
		Middle or Main Trap Sheet, 300 to 500 Feet	
		Lower (Anterior) shales, etc. 300 to 1,000 feet	First known dinosaur footprints Plants and fishes in black shale
		Lower Trap Sheet, 100 to 250 feet	
	New Haven arkose	Lower series of coarse sandstones, shales and conglomerates with intrusive sheets and dykes of trap 5,000 to 6,500 feet	<i>Clepsysaurus validus</i> <i>Clepsysaurus</i> (in New Jersey) <i>Stegomus arcuatus</i>

Gneisses, schists, and granites, Pre-Mesozoic

fore, to confirm the conclusion already put forward that the Triassic fish fauna of eastern North America is of a more or less manifold nature, and corresponds in a general way to the interval between the Upper Muschelkalk and the basal division of the Keuper in the Mediterranean region."

So far as the terrestrial vertebrates are concerned the evidence is at present less conclusive. *Clepsysaurus* spp. and *Stegomus arcuatus* from the lower series of coarse granitic sandstones below the lower (anterior) trap sheet are most nearly allied to *Myriosuchus* and *Aëtosaurus* respectively, from the Stubensandstein (Middle Keuper) of Württemberg; while the first recorded dinosaur footprint is from the lower (anterior) shales in the Connecticut valley in America, and, if I am not mistaken, from the Triassic conglomerate of South Wales, Upper Keuper in age, in Europe (Sollas 1879). The very extensive footprint fauna from Storeton near Liverpool (Beasley 1906), which is of Lower Keuper time, contains quadrupeds exclusively, all of which are very unlike the recognized tracks of dinosaurs.

In the Connecticut valley the upper (Portland) series of sandstones and shales contain the footprints in great profusion, and in fewer instances the bones of dinosaurs and other forms of the newer Newark fauna, all of which are apparently not earlier than the Upper Keuper.

THEORIES REGARDING DEPOSITION OF SEDIMENTS

In a region of the classic interest which envelops the Connecticut valley, embracing as it does some of our most venerable seats of learning, and cradling some of America's greatest geologists, it is not surprising that discussion as to the origin of the Newark deposits should have been animated. The theories of the method of deposition vary all the way from submarine through estuarine to continental, and involve a considerable range of climatic conditions as well.

THEORY OF TIDAL ESTUARY

Sir Charles Lyell who traveled extensively in North America in 1841-2 was greatly interested in the fossil footprints and attendant phenomena of the Connecticut valley which he saw in Edward Hitchcock's collection at Amherst, Mass., and especially at Smith's Ferry near Northampton where one can still see the huge footprints of *Eubrontes giganteus* impressed upon the sandstone near the Connecticut River. Lyell had previously seen the footprints of recent birds and the small depressions caused by a passing shower impressed upon the red mud deposited by tides along the tidal flats of the Bay of Fundy; and he was drawn to the conclusion that the method of origin was similar in each case. The Bay of Fundy is a great tidal estuary and seemed to imply that the Triassic Connecticut valley was comparable.

This theory was also described in detail by Kümmel for the New Jersey area and by Emerson for Massachusetts as set forth in the 1915 edition of this Bulletin. It is now effectually disproved and the Tidal

Estuary hypothesis becomes of interest only as an incident in the history of geologic thought.

It is now replaced by the theory of Continental Deposition.

This theory of Continental Deposition was set forth by Davis in 1898, pp. 32-34, from which I quote the following:

"Every pebble, every grain of sand, every particle of silt, is best understood as having been made in the manner of to-day—detached by weathering from the adjoining land surface and moved downhill in the creeping soil cap, carried down valleys by the wash of streams, or drifted from deltas into shallow lakes. There may have been storms and floods then as now, but there is no sufficient reason for supposing that Triassic time was significantly more unquiet than is the present. As the hills of New England are weathering and wasting before our eyes, as the streams are flowing down their valleys, so can we best picture them on the ancient New England of Triassic time. Only in this deliberate manner must the accumulation of one stratum on another be imagined. Even the coarse boulders of the marginal conglomerates, such as occur inside of the Pond and Totoket crescents, must have long rolled along the water courses from their source, and must have witnessed the passage of a great volume of finer materials over their heads before they were finally buried."

THE PHYSICAL ENVIRONMENT

The weight of evidence seems to show that the physical environment within which the animals of the Triassic lived, was connected with the several broad depressions along what is now the northern Atlantic coast. It is, nevertheless, inconceivable that creatures of such ample locomotive powers as the majority of the Connecticut valley remains would imply were limited to the actual depressions, but they must have roamed far and wide across the uplands as well, though naturally records of their wanderings would only be made where sedimentation was in progress.

CLIMATIC INDICATIONS

The climatic conditions of Triassic time may be judged by three criteria: the character of the sediment itself, the physical phenomena impressed upon the strata, and the evidence of the organic life.

The climatic conditions of Newark time have long been a controversial problem. In the 1915 edition the writer followed very largely the conclusions of Professor Joseph Barrell whose untimely death cut short a career of eminent promise.

Barrell worked at great length on the evidence then available and concluded that a semi-arid climate with long periods of drought separated by times of torrential rains was implied by the various phenomena to be seen in the Trias of the Connecticut and other sediments of Newark time. In other words, a climate of semi- or sub-aridity. Barrell



PLATE I.—Slab showing the passage of two dinosaurs after a shower. The larger footprints are those of *Steropoides diversus*; the smaller those of *Argoides minimus*. Cat. No. 2030, Y. P. M., from near Turners Falls, Mass.

Courtesy of the Yale Peabody Museum.

set forth his theory in Bulletin No. 23 of the Connecticut Geological and Natural History Survey (1908, pp. 188, 259).

EVIDENCE OF ORGANIC LIFE

The animals of the Connecticut Trias, which will be discussed more fully in a later chapter, in so far as they throw light upon past climatic conditions, include the remains of at least two species of shells, both belonging to the fresh-water Unionidae. The presence of the shells implies more or less permanent waters, either in slow moving or impounded condition. The one insect reported from the valley is found in great abundance at Turners Falls, Massachusetts, and has been described as the aquatic larva of a neuropterous insect, hence again implying the presence of waters of some duration. If the period of larval life was equivalent to that of the ephemerids of to-day, the water must have continued not one season alone but three. This may, however, have been an annual insect the larval life of which would require but a transitory stream.

The invertebrate trails show no characters which would debar them from such a climatic environment as Barrell has assumed for the Connecticut Trias. Fishes are without exception ganoids; and, while confined stratigraphically to two or three black shale bands, their geographical range is from Turners Falls to New Haven. They may be, however, all of fresh-water affinities,¹ and may well represent the recurrence of periodical climatic cycles of greater than the average humidity and consequent expansion of the aquatic habitat, or a disturbance of the drainage, climatic conditions remaining constant. The origin of these black shale bands will be discussed in detail below.

THE PLANT-BEARING SHALES

It will be noticed that almost all the known plants in the Connecticut valley area come from the fish-bearing black shales, which apparently represent lakes or swamps due to the damming up of the drainage in certain areas. In such areas of arrested drainage, the vegetation would naturally be more abundant than over the rest of the valley; though it may be that the relative abundance of vegetable fossils in these localities is due chiefly to the greater chance of preservation of organic material where oxidation is prevented by immersion in water.

Exactly what changes dammed up the drainage here and there, producing lakes and swamps, our knowledge is insufficient to determine. Two suggestions are, however, worthy of consideration.

A number of the localities where the black shales have been observed are near the eastern border of the Triassic area. It is altogether possible in these cases that the damming back of the waters may be due to the growth of alluvial fans formed by detritus coming down

¹Eastman 1911, p. 21, says: "While there is nothing in the character of the fossil fishes which would prove conclusively whether the deposits were formed in salt or brackish or fresh water, the physical character of the deposits and the fossils other than fishes found in them make it substantially certain that the deposits are not marine."

from the Eastern Highlands. Where such fans are so frequent as to come in contact with one another, pockets are often formed in which the imperfect drainage gives rise to local lakes and swampy areas, as in the Rhone Valley or Lake Tulare in southern California.

It is also noteworthy that all but one of the well-known localities of the black shales belong to two horizons which fall within the limits of that great epoch of vulcanism to which belong the three great contemporaneous sheets of trap and probably also the intrusions of trap. The black shale at Middlefield, Conn., belongs to a horizon later, but not much later, than the time of the outflow of the upper (posterior) trap sheet. It is altogether supposable that the events connected with such an epoch of vulcanism may have produced changes of the surface which would result in extensive disturbances of drainage.

Paul Krynine in a marginal comment on this manuscript says: "I have discovered and described another black shale horizon at the very base of the Triassic (Forest Hills). [There is, however] no vulcanism here."

Doctor Krynine, in his recent review (1950) of the climatic conditions of the Newark Trias¹, departs widely from Barrell's hypothesis of a semi-arid climate in favor of one of a hot and humid climate with an abundance of rain followed seasonally by a prolonged interval of drought of some three or more months' duration before the beginning of another pluvial period. Krynine speaks of the long duration of Newark time which probably lasted for several million years. He says further (p. 180): "Many climatic changes may have taken place during such a long period of time . . . as judged by the homogeneous character of the sediments, . . . these changes must have been rather in the nature of fluctuations (at times fairly pronounced) superimposed on a general climatic background. It is suggested that this general background was one of a relatively high uniform temperature, and pronounced but seasonally distributed rainfall, a climate of the type found at the present in tropical and sub-tropical savanna regions."

In support of these conclusions Krynine presents the following facts (pp. 180-181):

- "1) Extensive red beds containing locally derived red detritus suggest strongly a warm and *humid* climate.
- "2) Widespread swamp deposits covering thousands of square miles in warm regions are not known at present outside of humid districts.
- "3) Differential pre-diagenetic [diagenetic] weathering of local sedimentary detritus and the interbedding of variegated, alternative fresh and decayed layers is a feature of sedimentation in a savanna or monsoon climate close to a rugged source area.
- "4) Large-scale arkose deposits can easily form and be preserved in an extremely humid climate if the rainfall is seasonal and an adequate highland topography is at hand.

¹Bulletin No. 73 of the Connecticut Geological and Natural History Survey.

- "5) The same is true of fanglomerates. Local red detritus and organic material within the fanglomerates themselves confirm this view.
- "6) The abundance of desiccation marks suggests a marked dry season.
- 7) [Casts of soluble salts are a function not so much of climate as of barred drainage under very local conditions.¹]
- "8) The structure of the lower lava [trap] sheet may suggest extrusion upon a thoroughly water-soaked land surface.
- "9) There is no satisfactory evidence either of glacial or eolian action.
- "10) Part of the Triassic fauna indicates the presence of large permanent water bodies. The habitat of the rest is debatable or obscure. The total numbers of the reptilian population can be understood best if a warm humid climate is assumed to account for the large amount of vegetation necessary to support such a population, which included very large herbivorous [?] forms.
- "11) The flora of the Connecticut Valley Triassic can best be explained by a warm humid climate of the savanna type."

ENVIRONMENT AND LANDSCAPE OF THE NEWARK EPOCH

Krynine's conclusions are (pp. 195-6):

"Central and Western Connecticut [and Massachusetts] during Newark time can be pictured as a wide flatland bordered on the east by the steep but relatively low hills of the Great Fault scarp and to the west merging insensibly into the somewhat similar flatland of southern New York and New Jersey. The interfluvium between these two basins may have been so low as to lack any topographic expression, but it probably still was a divide between the two sedimentation basins of Connecticut and New Jersey. A master stream meandered over this flatland, probably flowing southward. Rapid deposition of material from the scarp region was building large alluvial fans and flood plains with a western slope, but continued subsidence of the basin due to eastward tilting along the Great Fault kept the surface almost flat, although a very small but still effective westward slope provided for adequate dissection and drainage. This equilibrium, however, was delicate, and as soon as it was disturbed in Meriden time, extensive lakes and swamps covered the flatland. This disruption was possibly the result of a damming action by the lava sheet immediately after the first extrusion, but probably due to more complex causes such as regional sagging of the basin surface due to structural warping some time after the extrusion of the thick middle lava sheet.

"The climate was hot and seasonally very humid. During the wet season heavy, long-continued rains transformed the flatland into a vast, sticky, water-soaked morass. Torrential rivers, heavily loaded with coarse detritus, roared westward from the hills. The gentler rains reworked and transported the red clayey material and deposited silt-stones and shales.

¹Revised by Krynine. Personal communication, April 4, 1952.

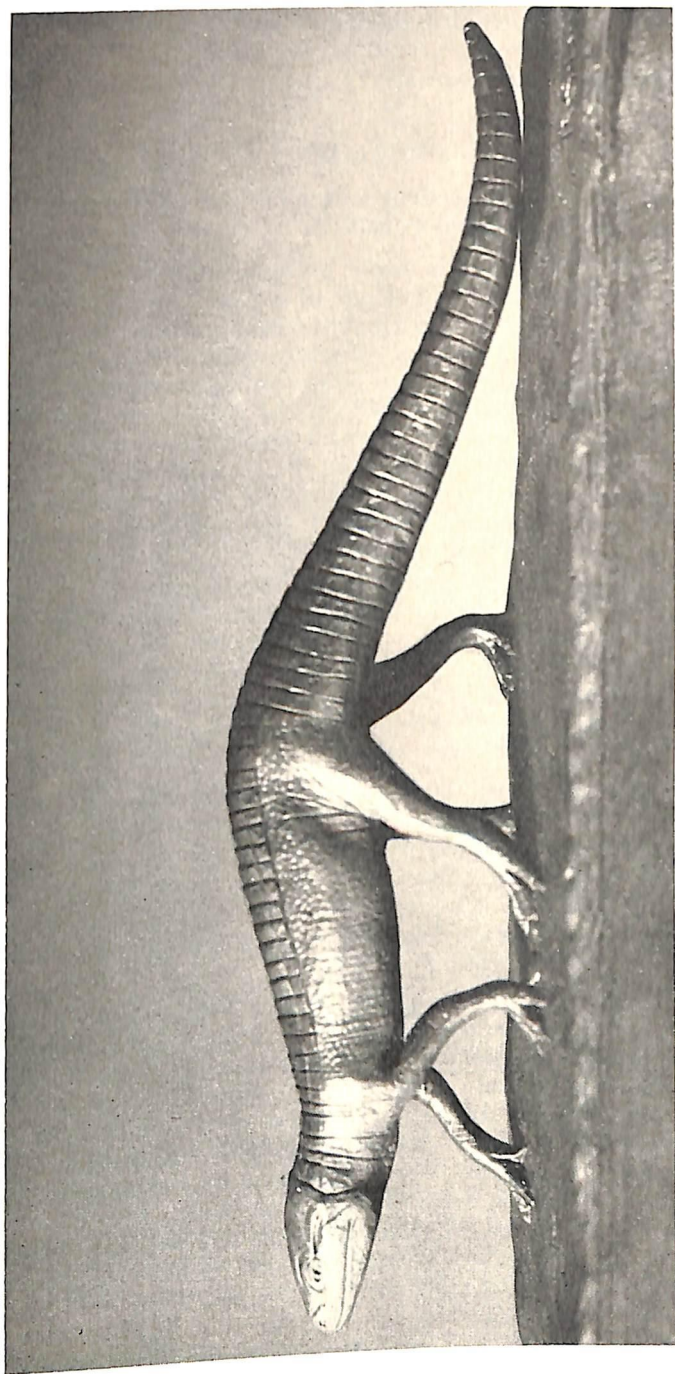


PLATE II.—Restoration of the pseudosuchian *Stegosuchus longipes* (Emerson and Loomis). From a model by Lull.
One-half natural size.

"During the dry season a broiling sun was beating upon the Connecticut savanna, caking and cracking the red soils. However, dense and luxuriant forests extended for several hundred yards on each side of the numerous watercourses, providing food and a cool shelter for the reptilian denizens of the Newark."

RÉSUMÉ

The story of the Connecticut valley, as the evidence at hand now reveals it, may be summarized as follows:

Far back in the remote Triassic period, when the Age of Reptiles was yet young, there were laid down in a gradually deepening trough in the older rocks the great accumulations of gravels, sands, and clays, interbedded with vast lava sheets, which constitute the sediments of the Newark system. The older notions of the submarine or estuarine origin of these rocks have been abandoned on the ground of their containing no relics whatever of marine or even brackish-water origin, and of the apparent difficulty of accounting for the deposition of the sediments except by tidal currents. On the other hand, evidence seems to point to continental deposits, the result of the ordinary subaërial agencies of winds and rains and rivers, to account for the accumulation of vast deposits in the course of time. The origin of the sediments was the wasting of the older rocks which formed the limiting highlands on either side of the depression: and the organic remains, all of fresh-water or terrestrial origin, testify to the presence from time to time at least of standing bodies of water of considerable extent; of seasonally, if not continually, flowing rivers; and of extensive land areas with slowly drying pools left after the pluvial seasons.

The vegetation bore the mark of antiquity in its monotonous sombre greens, for brilliantly colored flowering plants had not yet appeared. The plants were of three main sorts: ferns, cycads, and conifers, looked upon by existing animal life as undesirable food, but which for utter want of a better must have tempted some of the denizens of Triassic time, for we have evidence of mild-mannered herbivores among the rapacious devourers of flesh.

Of the organic remains, those of vegetable origin consist of the impressions and casts of trunks of trees, some of the latter found at Portland, Connecticut, being of such size as to indicate a stream of no mean transporting power; and of the impressions of leaves, twigs, and fruits, occasionally containing a delicate film of carbon which preserves the most intricate detail with wonderful fidelity. Here and there the vegetal remains were of sufficient abundance to lead to the production of black bituminous shale bands, formed during periods of the accumulation of waters which supported a teeming population of fishes; but never within this area were conditions ripe for the formation of beds of coal such as are found in the Newark beds from Virginia southward.

Animal life left its record rarely in the form of shells or bones, but in marvelous abundance in trails and footprints, some of great

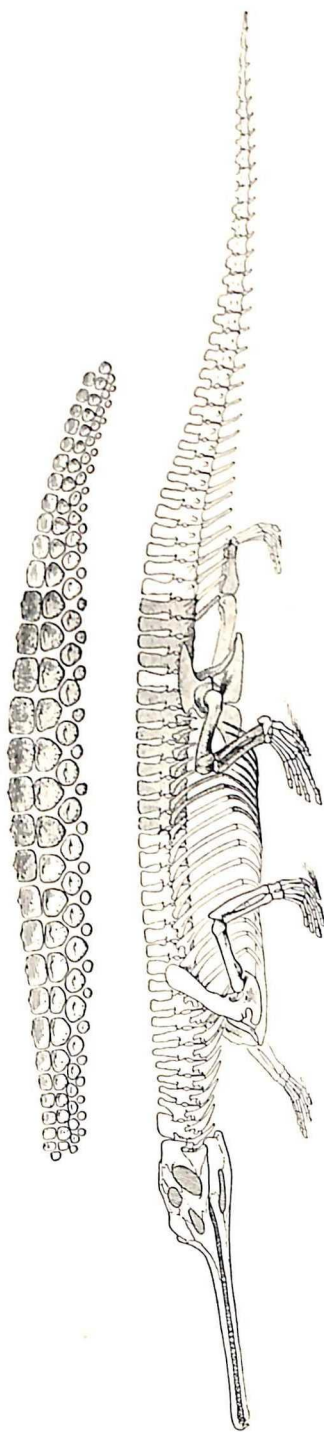


PLATE III.—Skeleton of the phytosaur *Clepsysaurus manhattanensis*, from von Huene after Matthew. The shaded parts are those preserved in the Fort Lee specimen shown on Plate VII.

clarity of meaning, others of more difficult and questionable interpretation, yet others exasperating in their baffling obscurity.

Both vertebrates and invertebrates are thus represented. Of the latter the actual fossils are impressions of at least two species of shells, allied to the modern wide-spread fresh-water *Unios*, and a single aquatic insect species, occurring in profusion of numbers, which bears the unique distinction of being the oldest true insect *larva* known. Some of the trails are worm-like as though made by annelids, others show serially repeated footmarks in pairs, or fours or sixes or more, indicating the presence of other arthropods than *Mormolucoides* (see p. 34), many of which were doubtless insects, others myriapods, perhaps spiders and scorpions, and fresh-water crustaceans as well. Some of these are small and of wondrous delicacy; others, larger than the trails of any insects or fresh-water crustaceans now known, must represent giants among their race.

The fishes, all of the old-fashioned armored "ganoid" sort, have been alluded to as occurring in abundance from time to time in the black shale bands, representing swamp or lake deposits with a luxuriant growth of plants.

The terrestrial vertebrate skeletons are all reptilian remains; three, those of phytosaurs, remotely related to living crocodiles, and, in one instance at least, ecologically equivalent to the fish-eating gavials of the Far East. The others are *Pseudosuchia* or dinosaurs of small size and representative kinds, neither the largest nor the most specialized which lived during the time of which we speak being known to us. The dinosaurian skeletons were those of essential contemporaries, and therefore in themselves throw no direct light upon evolutionary history.

The footprints doubtless represent two, possibly three, great classes of terrestrial beings: Amphibia of salamandrine form were perhaps present, and also representatives of the more archaic armored stegcephalians as well, though one cannot indicate the tracks of either with assurance. Of the reptiles, the possibilities of time and place would indicate dinosaurs among the more familiar forms, and these unquestionably were represented in the fauna; and among those less known the *Rhynchocephalia*, phytosaurs, thecodonts, and theromorphs are within the possibilities. Whether or not birds were present is a mooted question. The elder Hitchcock considered all the bird-like tracks to have been of avian origin, but the discovery of dinosaurian remains soon swung popular if not scientific opinion to the opposite extreme, and all the tracks were believed to have been made by dinosaurs. I believe, in most instances, this group of footprints is demonstrably dinosaurian. There are some, however, of which I am not so sure; but the only final proof of the existence of Triassic birds will be the actual discovery of their remains, for the earliest yet known, *Archæopteryx*, of the Upper Jurassic, lived millions of years subsequent to the close of Newark time.

Geologically, the history of Newark times is a tremendous drama, of which the prologue speaks of the degradation of the ancient hills,

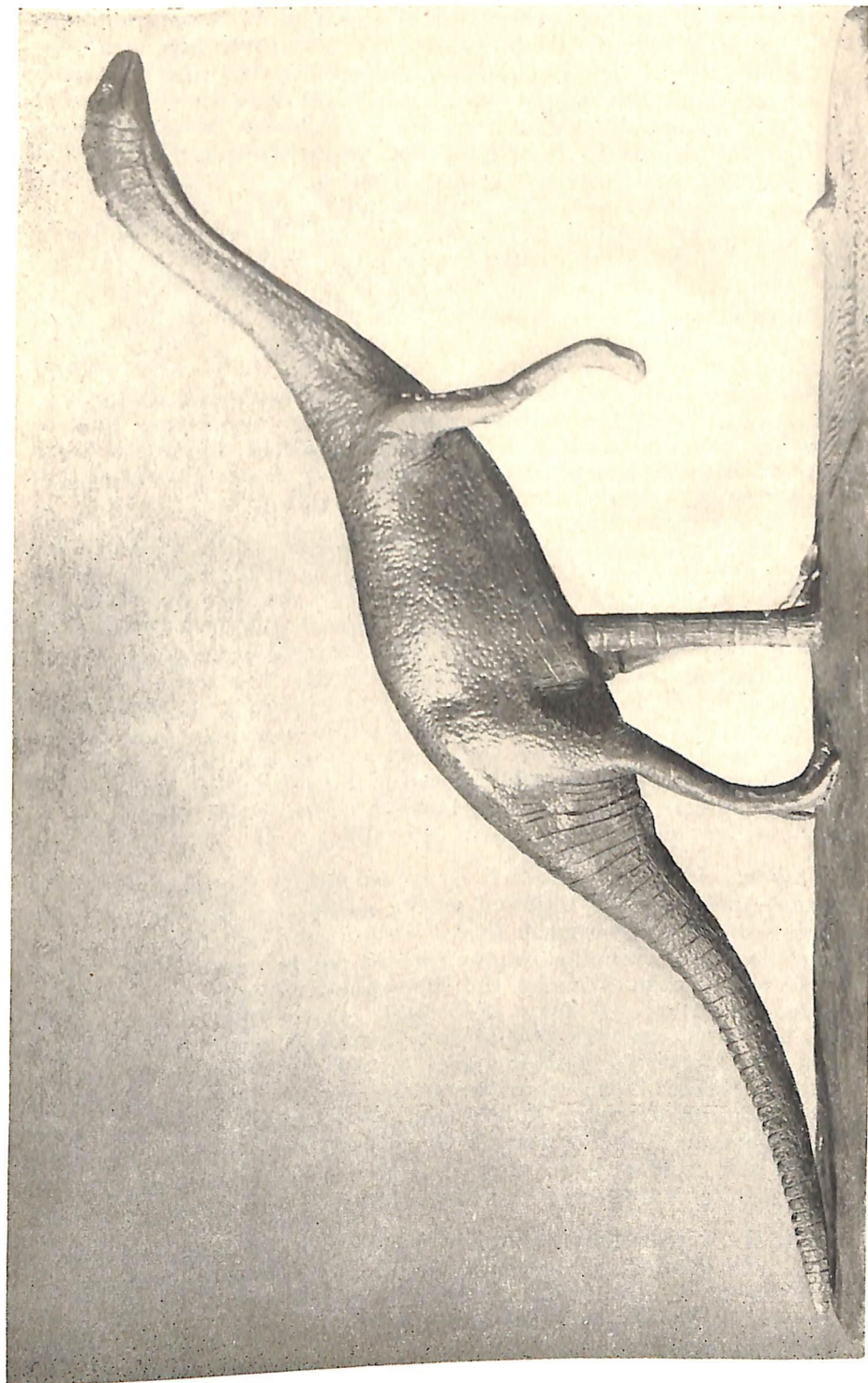


PLATE IV.—Restoration of the prosauropod, *Yalesaurus* (*Anchisaurus*) *colurus* (Marsh). From a model by Lull. One-twelfth natural size.

and the setting of the stage in the form of an extensive though relatively slight depression with the establishment of the sediment-bearing drainage from the environing upland. Four great acts of which the first and last are much the longest, succeed each other in time, separated by entr'actes of appalling grandeur, when vast sheets of molten rock well from the depths, spreading far and wide, blotting out the old and preparing the stage for new and different players. Of the sequence of the scenes within the acts the order is not so surely recorded, since they differ in their position in the valley, in the nature of the sediment in which their record is written, and in the forms that people the stage. The whole drama is incredibly long as we measure time, for each succeeding day, with its dawning, its morning hours, high noon, declining sun, and long night, adds but the smallest increment to the gradually accumulating sediments, though, as one has said, "neither time nor space flows evenly," and there were tempestuous days whose contribution to the mass makes up for the calm passage of those to follow. Yet, when one thinks of the two and one half miles of accumulations which these days represent, he can feebly grasp at a realization of the extent of Newark time.

During the long first act in the course of which are laid down the five or six thousand feet of the lower series of coarse granitic sandstones, we have but little record of the action. But two entrances are recorded, one of which is at New Haven where appears the heavily armored *Stegomus arcuatus*, whose habits we can scarcely conjecture, as the burial of its body in river sediment means little. The second scene at Simsbury is more intelligible because, while part of a shoulder blade only is preserved, it is from a representative of a genus, *Clepsysaurus*, which is almost completely known; hence we are justified in applying the old Cuvierian principle and reconstructing not only a long-snouted fish-eating animal from a single bone, but the stage setting of its fish-supporting aquatic environment as well.

This act closes with the first lava outpouring, the so called lower (anterior) trap, which is followed by the second act, that of the lower (anterior) shales, interesting in that it includes the first fish- and plant-bearing black shale deposits, followed in the region round about Mount Holyoke and Mount Tom by the first recorded appearance of dinosaurs in the valley. Of these, *Eubrontes giganteus*, one of the very largest, is among the first, possibly representing a form like the larger genera well known from their bones in the Old World. Others are the larger species of *Anchisauripus*, indicating the presence of *Ammosaurus*-like forms as well. This second act with but a thousand feet or less to its credit is the briefest of all, and the entr'acte following, as befits the middle of the drama, is the most stupendous, with its accumulation of 300 to 500 feet of lava, constituting the main trap sheet.

Act III, during which the upper or posterior shales were laid down, is still more prolific of animate records, for the known footprints not only increase in number, but here for the first time we find those of *Anomæpus* giving the earliest reasonably sure record of the advent of plant-feeding dinosaurs, while that of *Grallator cursorius* shows that

accompanying their larger, fiercer brethren are the lighter, more agile dinosaurs of compsognathoid type. This act includes other scenes during which plant- and fish-bearing black shales are accumulated. The relative duration of these upper (posterior) shales is somewhat greater than that of the lower (anterior), but is followed by the smallest of all the lava outpourings, that of the upper (posterior) trap.

It is only in the final act that the profusion of the cast becomes evident, for at various levels within the 3,500 feet of its accumulations, and more notably toward its close, at Portland, around South Hadley, and about Turners Falls, are recorded by far the greater number of the known genera and species of the footprints of the Trias, while equivalent beds, mainly from South Hadley southward to Manchester, have yielded all the osseous dinosaurian remains.

Here more than in any other act of paleontological history one is conscious of an obscuring drop-scene in the middle distance, behind which may be seen with tantalizing clarity the passing and re-passing feet of a great host of players, some rapidly as though impelled by urgent impulse, others slow-moving, ponderous, the like of which the paleontologist has never seen. Occasionally one passes before the curtain, and there while fully exposed to our scientific vision a tragedy is enacted, for bones are ever symbolical of death; but the footprints are those of creatures in the full tide of life.

PART II. THE TRIASSIC LIFE

THE FLORA

An excellent summary of the Triassic plant life is given by Ward (1900, p. 222), from which I extract the following: The earliest mention of fossil plants in the Connecticut valley is "that by Dr. Edward Hitchcock, in the American Journal of Science for 1823, in an extended article read before the American Geological Society on September 11, 1822. Neither of the two objects found is specifically determinable, the first being some sort of cane or grass, the other a coniferous branch, possibly *Palissya* or *Voltzia*. The first was found one-half mile south of Newgate Prison, the second at Sunderland, in Massachusetts.

"The first mention made of the petrified tree found in the Southbury area of the Connecticut Trias . . . was a paragraph devoted to it by Dr. Hitchcock in his Miscellaneous Notices of Mineral Localities, with Geological Remarks, in 1828, describing a fragment from it obtained by Dr. Smith of Southbury, broken off by a man who had mistaken it for a recent stump and ruined his axe upon it." Later investigations of Professor Bailey of West Point prove this tree to have been coniferous.

The plant localities enumerated down to the time of the publication of Newberry's Monograph on the "Fossil Fishes and Fossil Plants of the Triassic" (1888), in the chronological order of their publication, are as follows: Newgate Prison, Conn., and Sunderland, Mass.; Southbury, Conn.; "Hadley, Conn.," supposed to be South Hadley, Mass.; Deerfield and Greenfield, Mass.; Middletown, Conn.; Enfield Falls, Mass.; Suffield, Southington, and Durham, Conn.; Mount Holyoke, Mass.; Bristol, Conn.; Middlefield, Conn.; Mt. Tom, Mass.; and the quarry of Roswell Field at Gill, and Turners Falls, the last two probably identical.

Ward says further (p. 226):—

"The above enumeration brings the record of paleobotanical discovery in the Trias of the Connecticut Valley and New England areas down to the date [1888] of Dr. Newberry's Monograph of the Fossil Fishes and Fossil Plants, to which reference has already been made. In this he gives a sketch of the Triassic, and includes 17 species of fossil plants. They were collected at Sunderland, Massachusetts, at Durham and Middletown, Connecticut, and at Newark and Milford, New Jersey. . . .

"Of recent collectors in this section by far the most successful has been Mr. S. Ward Loper, of Middletown. Mr. Loper was in the field at the time of our visit, and we met him at Tariffville, Connecticut, at which place he had discovered a plant-bearing locality. There being

no true coal mines in the Connecticut Valley Trias, the mode of occurrence of the fossil plants is, of course, somewhat different from that in Virginia. It is equally true here, as in Virginia, that fossil plants are not found in the red sandstone, but are confined to the dark shales, and those in the Connecticut Valley occur for the most part in close connection with the trap ridges of that region. They are usually found at the margin of the shales near their contact with the trap. The locality at Tariffville was in close contact with one of the secondary trap ridges located on the eastern side of the main ridge, which, in the general trend of these ridges, places it higher in the Trias, geologically speaking, or, as Professor Davis expresses it, 'posterior.' From what Mr. Loper told us, and from numerous observations upon localities from which fossil plants have been previously reported, it would seem that they usually occur in this position. . . .

"Besides examining the Portland quarries and those of Turners Falls and Gill, Massachusetts, where no vegetable remains other than those presently to be named occur, we visited several places in Connecticut where Mr. Loper had obtained fossil plants, especially at Westfield and Highlands. In the Portland quarries there occur large logs clearly representing Triassic trees embedded in the red sandstone and now thoroughly silicified¹; but besides these and the fine specimens of *Dendrophycus* [*vide supra*, p. 24] which occur there, nothing of a vegetable nature seems to have been found. At Turners Falls careful investigation was made in the red shales bearing the tracks so celebrated in that locality, and under the guidance of Mr. T. M. Stoughton we visited all the important places from which specimens of interest had been taken. We saw in these beds nothing that could be called vegetable, and it seems very doubtful whether any plants either grew or were ever transported by any agency into the riparian clays in which the Brontotheria [Brontozoa] and other saurians left their footprints in such profusion."

In this connection mention should be made of a small slab of gray shale, preserved in the Peabody Museum at Yale, from the footprint locality at the Horse Race, Montague, Massachusetts, one surface of which is covered by a mass of fragments of vegetation consisting in the main of twigs and stems of conifers. They are very distinctly seen because of the film of carbonaceous material which still adheres to most of the impressions; but if the carbon had not been preserved, or if a monotone cast were taken of the surface, the plant remains would hardly be recognized as such at all. This would account for much of the *apparent* dearth of plant remains except in the black bituminous shale bands in which oxidation has been carried to a relatively slight extent as compared with the red shale and sandstone strata.

In a joint paper by Professor Davis and Mr. Loper read at the Washington meeting of the Geological Society of America in December, 1890 (Davis and Loper, 1891) are enumerated the fossil plants and fossil fishes, found by the junior author, with their stratigraphical pos-

¹These logs are certainly not in any proper sense "silicified." If they are of vegetable origin, as is probable, they are not petrifications but casts.

ition, "showing those that are confined to the anterior and to the posterior shales, and those that are common to both. This enumeration includes 13 plant forms, 11 of which are specifically named. Six of these forms are confined to the anterior and 2 to the posterior shales, while the remaining 5 are common to both situations" (Ward).

The plant lists made up by Davis and Loper from the black shale areas give the following from the lower shales:—of the Coniferæ, a ginkgo, *Baiera münsteriana*, *Pachyphyllum simile*, and *P. brevifolium*; of the cycads, *Cycadinocarpus chapini*, *Otozamites brevifolius*, and *O. latior*; of Equisetaceæ, a small undetermined *Equisetum* (?), and "calamite-like stems, with head"; and a plant, *Loperia carolinensis*, of uncertain botanical relationships, "probably monocotyledonous, perhaps aquatic" (Newberry). There is also found a fern, *Clathropteris platyphylla*.

The upper shales have produced *Otozamites latior*, *O. brevifolius* (the latter doubtful), *Cycadinocarpus chapini*, *Loperia carolinensis*, and a small undetermined *Equisetum* (?), in common with the lower; and in addition contain the cycadacean, *Ctenophyllum braunianum*, and the rush, *Equisetum rogersi*.

In addition to these plants of the black shale, certain footprint localities have produced ferns, as *Teniopteris* in the gray sandstones of Mount Holyoke, and a very doubtful one described as *Clathropteris* at Mount Tom and at Gill, though Fontaine concludes that neither of these is *Clathropteris*, but probably *Dictyophyllum* or *Camptopteris*.

Field's Orchard quarry at Gill has also produced a cone which may be the conifer *Palissya*, and twigs of *Cheirolepis muensteri*. There is also a *Palissya*-like conifer impressed upon the gray shale from the Horse Race quarry at Montague. With the possible exception of the Mount Tom and Mount Holyoke specimens, these are all from localities in the upper series of sandstones and shales, and are therefore much younger than either the lower or upper shales.

THE FAUNA

THE INVERTEBRATES

ACTUAL REMAINS

In both vertebrate and invertebrate relics the proportion of known fossils to trails and footprints is much the same, the former being of such extreme rarity as to warrant special mention of practically every find.

Of the actual invertebrate fossils the species represented are but three—two known species of molluscs, and a single insect species of which fortunately there are numerous examples, all however from two or three localities in the neighborhood of Turners Falls, Massachusetts, except a few specimens found in a railway embankment near Middletown, Connecticut.

Phylum ARTHROPODA

Class HEXAPODA

Order NEUROPTERA

Family SIALIDÆ

Mormolucoides articulatus Hitchcock

This creature was first described by E. Hitchcock in 1858 (pp. 7-8, fig. 1, pl. 7, figs. 3-4), though Hitchcock considered it to be a crustacean, and its true relationships were discovered by J. D. Dana to whom Hitchcock sent specimens. Dana in a letter published in the *Ichnology* (p. 7) and bearing the date of May 11, 1858, writes as follows:—

"I have taken up your specimen over and over again, trying to resolve doubts, but still remain undecided; my mind has gradually come to the suspicion, if not the belief, that it is a larve of an insect, and not crustacean. I question much whether the depressions on the right side are impressions of true legs; and those on the other side are still less like anything of the kind; they appear to mark a line or suture in the shell of the segment. I agree with you that your artist has not done justice to the specimen. I have made a rude sketch, merely to indicate some of the characteristics which he has failed to bring out, and which appear to be of special importance. I should regard A to C as corresponding to the head and corselet of the larve (A the head, B to C the three segments of the corselet), and C to D as the abdomen. As I cannot make it crustacean, and my knowledge of insects is quite limited, I return the specimen without attempting a description.

"*Postscript.*—The larve was probably a larve of a neuropterous insect, which often has false legs along the abdomen; but if so, it is surprising that there are no legs to the corselet, neuropterous larves having three pairs."

The "rude sketch" to which Dana refers was published as fig. 1 of the *Ichnology*, and later on a reduced scale as fig. 1164 of Dana's "Manual of Geology." Le Conte confirmed Dana's reference of the insect to the Neuroptera, placing it within the family Ephemeridæ, which induced Doctor Hitchcock to change the name of the fossil to *Palephemera mediæva*.

Scudder first decided (*Geol. Mag.*, v, pp. 218-220) that the insects were coleopterous larvæ, and suggested later that they "reminded one of some Cembrionidæ," but said that the only larva of that group whose history is known "lives on the roots of plants and would not be likely to occur in such a deposit as that in which these remains were found." Dr. A. S. Packard (1890) in turn expressed the opinion that they were "aquatic coleopterous larvæ, belonging perhaps near the family Heteroceridæ." Scudder later had the opportunity to examine all the remains in the museums at Amherst College and at Yale, some hun-

dreds altogether, and came to the conclusion (1886) that, while they present considerable variation, the specimens all pertain to one species to which of course Hitchcock's first name should apply. Scudder's description gives the following main characteristics:—

"Number of segments apparently thirteen, of which one constitutes the head, and three, sometimes very obscurely differentiated, the thorax. There seem at times to be lateral anterior lobes to the head, always separated from it by a more or less well marked suture, which are probably inferior appendages showing only when projected forward. The head is rounded, usually a little broader at the base than in the middle, slightly broader than long, the front well rounded.

"The three thoracic segments are almost invariably larger, generally considerably broader than the others, and are often distinctly differentiated as a separate region, both by their breadth, greater than that of the uniform segments behind, and by the slight forward inclination of their sides. Usually the middle thoracic segment is larger than the front thoracic segment, so that their relative size is II, I, III; but not infrequently the front one is the largest, and there are some cases where the broadest part of the body is behind the thoracic segments, and the order of breadth in the thoracic segments is III, II, I, which changes the whole aspect of the insect. In some instances the form reminds one of the larva of a longicorn beetle while the other extreme recalls some of the Silphidæ. An average or normal thoracic segment is about three times as broad as long, subquadrate, with very slightly concave front margin, and a little more distinctly convex hind margin, the sides well rounded, and the hinder angles more broadly rounded off than the front lateral angles, giving a slightly sublunate form to the entire segment. These segments are further marked by more or less distinct lateral marks, usually impressed, either angular or rounded, which are the only indications, if such they are, of appendages. Whatever they are, Scudder is emphatic in the statement that there is nothing else on a single specimen of those examined by him—many hundreds in number—which could be referred to legs (*vide infra* p. 36).

"The abdominal segments invariably taper to some extent toward the tail; sometimes the tapering is scarcely visible on the anterior segments, and it is always more pronounced posteriorly, though here again there is variation. As a very general rule, the segments are quadrate, with very gently convex sides and slightly and equally rounded anterior and posterior angles; but in a few cases the anterior angles are considerably more rounded than usual, and the posterior angles, besides being square, are furnished with a faint posterior extension, bristle, or tapering cluster of hairs (it is impossible to say which, but the last is most probable). This same posterior set of appendages may be seen more or less distinctly in some of the other specimens, where the segments have the posterior angle as rounded as the anterior.

"The surface of the abdominal segments is in general flat, but not quite uniform, at least on many specimens. There appear to be two kinds of inequalities, one of which from its infrequency and position

seems to be accidental, perhaps due to pressure. This is seen in sharp lines close and parallel to the margin. The other, however, though often obscure, is too common to be so considered, and consists in a longitudinal series of slight ridges, laterally convex, and extending the whole length of the abdomen, dividing the segments into equal or subequal transverse thirds, of which the middle third is apt to be the largest. . . . Besides these, there is nearly always some median mark of greater or less intensity, indicating probably the track of the alimentary canal. . . . It would appear tolerably clear that a slender alimentary canal, nowhere expanding into a well marked stomach, doubled sharply upon itself at or near the seventh abdominal segment, and again, by doubling at the hinder extremity of the fifth abdominal segment, resumed its former course, the whole of the sixth segment and at least a part of the seventh having therefore three sections of the canal passing through the middle. . . .

"It now remains to speak of the curious variations of the terminal or ninth abdominal segment and of its special appendages." This segment is generally "quadrate but well rounded, tapering and about two-thirds as large as the preceding joint. In some cases, however, . . . it is very small, and its separation from the preceding joint is hardly noticeable, while at the other extreme . . . it is scarcely smaller than the preceding segment and longer, if anything, than broad. But the most interesting feature in this segment is the discovery in a few specimens . . . of slender styles, a little shorter than the penultimate segment, directed backward and a little divergent; and a much shorter pair, or perhaps only projections of the pygidium, lying between the longer styles.

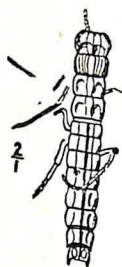


FIGURE 1.
*Mormolucoides
articulatus*
Hitchcock. Aquatic
nymph on black
shale. Twice natural
size. After Lull.

"As there is not a single specimen . . . showing a lateral or even a partially lateral view, the insect could not have been cylindrical but must have been considerably flattened."

After comparing the characters of the larvæ of several coleopterous families and of the neuropterous families Perlidæ and Ephemeridæ, Scudder comes to the family Sialidæ, of which the larvæ are also aquatic. Speaking of these he says:—

"Here we find considerably greater range of characteristics, so that it is not so easy to recognize a common facies among them. But we may note one or two characteristics by which they approach much more closely our fossil type. All the appendages—antennæ, legs, and (often) the cerci—are shorter and slenderer than in the two groups last mentioned. In some, the comparatively insignificant. The mandibles in the two groups long in all that are known, may well be believed to be capable of modification in this regard. The abdominal segments are provided with lateral filaments, projecting antennæ at least are some are very stout, and, though long in all that are known, may well be believed to be capable of modification in this regard. The abdominal segments are provided with lateral filaments, projecting

backward from the posterior outer angles. The appendages of the terminal segment vary very much, some having a single median style of considerable length, others a shorter lateral pair, in some cases furnished apically with recurved hooks. The objections to considering this as the most nearly allied group are the considerable size of the legs even when least developed, the great size of the head, which is at least as large as the segments behind, and the slight differentiation of the prothoracic segment shown at least in its larger size."

I have been fortunate in the extreme in finding upon two counterpart pieces of the typical black slate from Turners Falls, collected by T. M. Stoughton and now in the Yale Museum, a fairly well preserved individual of this most interesting larva, in which some of the thoracic legs and one antenna are present, and which compare very well with those of the *Sialidæ*. As preserved, the antenna of the left side is filiform, showing five segments of equal length. It is not, however, attached at the lateral angle of the head as in the larva of *Corydalis cornuta*, but the insertions of the two antennæ were separated by a distance of about one-third the total width of the head, which would seem to preclude the presence of large mandibles, unless they were, as appears true, beneath the head rather than between the antennæ as in *Corydalis*. The thoracic legs are relatively longer and more slender than in *Corydalis*, and one at least shows four distinct tarsal segments. The specimen unfortunately is somewhat ruptured, so that the abdominal region is displaced a little to the left, and the limbs partially detached from the body so that the hinder pair seem to arise from the second or third abdominal segment rather than from the metathorax. In my figure (fig. 1) I have tried to correct the dislocation of the body, but the legs are drawn as they appear, the posterior one of the right side being curved over the abdomen. In this individual the number of segments is in doubt, there being twelve distinctly visible and probably traces of a very narrow anterior abdominal one in addition. The prothorax differs from the other thoracic segments by slight longitudinal furrows, four or five on either side, while the meso- and metathoracic segments are characterized by a slight median ridge and paired lateral depressions. The larva under consideration is of average size (about 15 mm. long), and gives no very marked evidence of representing a different species, even though the thoracic appendages are preserved, while, except for the anal cerci, those of the abdomen are not, a reversal of the conditions often seen in other individuals.

These further observations give additional weight to Scudder's conclusion "that *Mormolucoides* is probably the larva of a sialidan neuropteran. It has special interest from the fact that it is the oldest known insect larva."

The recorded localities for this insect are all within the Turners Falls region:—Montague, the Horse Race at Gill, and Turners Falls, Mass., and near Middletown, Conn.

Judging from the habits of the modern representatives of the family, their presence would seem to imply standing water of at least seasonal duration.

Phylum MOLLUSCA

The earliest allusion to a mollusc in the Connecticut valley is in the Ichnology (Hitchcock 1858, p. 6), in which a very brief description is given of a shell-like specimen found in the same sandstone with the fern *Clathropteris* from Mount Tom in Easthampton by Doctor E. Hitchcock, Jr. This is described as a "shell or mollusk—preserved, not petrified—which, although greatly injured, is allied apparently, to the rudistæ of Lamarck, especially to the sphaerulites and hippurites. This family of shells on the eastern continent seems to be chiefly confined to the Chalk formation; and though the specimen is too much injured to have its genuine character determined, this fact gives plausibility to the opinion that the deposit containing it is newer than the Trias. As it is the only shell that has ever been found in the sandstone of this valley, I give a sketch of it. The original is now in Amherst College. See Plate v., fig. 2." The figure is a lithographic drawing from which it is impossible now to draw conclusions as to the true place of the fossil. It does bear some superficial resemblance to the Rudistæ, judging from the picture; but this group of shells is exclusively marine, which alone precludes the possibility of the reference of the specimen under consideration to that group, for it is in association with a possible fern and not far removed from a footprint locality containing *Eubrontes giganteus*. The locality lies beneath the main trap sheet. Judging from the figure, however, it seems to be inorganic, doubtless a weathered-out concretion.

Class PELECYPODA

Family UNIONIDÆ

Genus *Unio*

Another discovery is that reported by Professor B. K. Emerson (1900, p. 58) as follows:—

"A few days ago my former assistant, Mr. Chas. S. Merrick, of Wilbraham, sent me a large slab of sandstone of a buff color, much stained by malachite, containing several indistinct casts of a unio-like bivalve.

"The shell seems to be one of those fresh- or brackish-water forms common in the Trias allied to the Unionidæ. It may be compared with the *Anoplophora lettica* Quenstedt (Pal., pl. lxiii, fig. 28), and may be called *Anoplophora wilbrahamensis*. It is a distinctly unio-shaped shell, 38 mm. long, 18 mm. high, 7 mm. thick. The exterior is smooth with fine lines of growth. The mantle impression is quite deep as preserved on the central portion of the length. The beak rises very slightly and the hinge line is long and straight, and there is in the figure what seems to be the impression of a long posterior tooth, and above this a slight groove at the place of attachment of the ligament."

Through the courtesy of Professor Emerson this slab was sent to me for further study, and I referred the specimen to Professor Schuchert who kindly made the following addenda:—

[Bull. No. 81]

There are on the slab at least fourteen imperfect impressions representing at least two species of undoubted *Unio*, the type of Emerson's species being similar to *U. alatus*. It should hereafter be referred to as *Unio wilbrahamensis*.

The second species, which I have designated *U. emersoni*, is quite distinct from the first but is too imperfect to characterize. It is also unquestionably *Unio*. *Anoplophora*, Schuchert said, is probably always marine, and the shells in question are doubtless in fresh-water deposits. The slab, which is a portion of an ice-transported boulder, the parent ledge of which is probably unknown and therefore not necessarily as far south in the valley as Wilbraham, shows little trace of oxidation, and gives evidence of having been deposited in permanent waters, the bottom vegetation holding the oxygen from the iron and thus preventing the typical red color of iron oxide. The yellowish color may be due to oxidation of carbonate of iron. This conception of the habitat is in keeping with that of present day Unios. Wilbraham, being toward the eastern side of the valley, is therefore near the summit of the Newark series stratigraphically.

INVERTEBRATE TRAILS

Owing to conditions of sedimentation and subsequent preservance which were necessary for the recording of such delicate impressions as those of the minute feet of arthropods, and of other invertebrate trails, but few localities have yielded these phenomena. The most remarkable locality is at the Lily Pond in Gill, Massachusetts, which has produced by far the greatest number of genera and species.

This does not imply that invertebrates were limited to this region but that they were probably as widespread throughout the valley as were the vertebrates, and this of course includes Connecticut as well as Massachusetts.

The founder of the science of Ichnology, Professor Edward Hitchcock, seems to have been troubled by few rules of nomenclature, and as a consequence changed the names of his various species at will, whenever he thought a name inappropriate or misleading. As a result the synonymy of fossil footprints has been complicated to a remarkable degree.

It happens that the first invertebrate trails were named in a paper published by Hitchcock in 1848 (Fossil Footmarks of the United States), so that in these instances the nomenclature dates from that volume. The Ichnology (1858) and the Supplement (1865) by Hitchcock added to the series and changed certain of the names, but the final summary was given by Professor Charles H. Hitchcock in 1889, who added one more named species and two unnamed new species to the list.

The last-named author summarized the known species as follows:—

Hexapod Arthropoda, 8 genera, 24 species.
Inferior Arthropoda, including larval forms, and worms, 10 genera, 16 species.

Mollusca, 4 genera, 6 species.

Incertæ sedis, 5 genera, 6 species.

This places the total number of invertebrates and questionable trails at fifty-two. In view of the number of undoubted vertebrate species known from the Newark system and the teeming numbers of living invertebrates, especially arthropods, compared with vertebrates, even under adverse climatic conditions, this number does not seem excessive. In fact, I imagine it may fall far short of the number of continental invertebrates of Newark time.

Phylum ARTHROPODA

Class INSECTA

Genus *Acanthichnus* E. Hitchcock

E. Hitchcock 1858, p. 150.

Lull 1915A, p. 56.

Generic Characters.—"Tracks linear; generally in two rows."

Genotype: *Acanthichnus cursorius*.

Acanthichnus cursorius E. Hitchcock

E. Hitchcock 1858, p. 150, pl. 28, fig. 1; pl. 31, fig. 1.

Lull 1915A, p. 56.

Holotype, Cat. No. 47/76 A. C.* from the Lily Pond, Gill, Mass.

Trail consists of two lines of single marks which vary in the length of the interval between the marks up to eight times.

Distance between the rows of tracks 4 mm.

Length of foot, about 3 mm.; of the step, 2 to 20 mm.

Acanthichnus alternans E. Hitchcock

E. Hitchcock 1865, p. 14.

Lull 1915A, p. 56.

Holotype, Cat. No. 55/59 A. C. from the Lily Pond, Gill, Mass.

Resembling *A. cursorius* in the small, simple tracks, but differing in the shortness and regularity of the interval, the greater width of the trackway, and the alternation of the footmarks of either row. The distinction between the two species, however, is not always clear.

Acanthichnus divaricatus E. Hitchcock

E. Hitchcock 1865, p. 15, pl. 7, fig. 10.

Lull 1915A, p. 57.

Holotype not recorded.

Of this species Hitchcock says: "If the spreading character of two rows of the tracks shown on fig. 10, plate VII does not indicate a species of Myriapod rather than insects, it should evidently take the name of *A. divaricatus*."

Evidently a very rare form for it is seemingly unrepresented in either the Amherst collection or that of Yale.

*A. C. = Amherst Collection.

Acanthichnus trilinearis E. Hitchcock

E. Hitchcock 1865, p. 14, pl. 6, fig. 11.

Lull 1915A, p. 57.

Holotype, Cat. No. 52/14 A. C. from the Lily Pond, Gill, Mass.

Similar to *A. alternans* except that in some places there is a line of tracks along the middle of the trackway. The intervals between the footmarks in some instances are almost obliterated. Evidently a very rare and doubtful species.

Acanthichnus alatus E. Hitchcock

E. Hitchcock 1865, p. 14, pl. 6, fig. 6.

Lull 1915A, p. 57.

Holotype not recorded.

Hitchcock's description of this form follows: ". . . [it] generally shows the same characters [as in *alternans*], and the outside row of tracks standing at right angles to the trackway have so much the aspect of oars or wings that I propose for it the name of *A. alatus*."

Acanthichnus punctatus E. Hitchcock

E. Hitchcock 1865, p. 15, pl. 6, fig. 13.

Lull 1915A, p. 57.

Holotype, Cat. No. and locality unrecorded. Characterized by "very minute linear feet and small punctures, nearly on a line."

Acanthichnus rectilinearis E. Hitchcock

E. Hitchcock 1865, p. 15, pl. 6, fig. 2.

Lull 1915A, p. 57.

Holotype, Cat. No. 53/13 A. C., locality unrecorded.

Feet minute, each pair often in triplicate. The linear character of the footmarks which is hardly distinctive suggested the specific name.

Acanthichnus anguineus E. Hitchcock

E. Hitchcock 1865, p. 14, pl. 7, fig. 4.

Lull 1915A, p. 57.

Holotype, Cat. No. 55/50 A. C. from the Lily Pond, Gill, Mass.

Trackway serpentine; the individual footmarks so near as to show almost uninterrupted lines. Very small.

Acanthichnus saltatorius E. Hitchcock

E. Hitchcock 1858, p. 151, pl. 38, figs. 4, 5.

Lull 1915A, p. 57.

Holotype, Cat. No. 36/31 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Tracks opposite, nearly parallel. Animal frequently jumping sideways, as a dancer, hence the specific name. This character and the extreme shortness of the pace distinguish *saltatorius* from *cursorius*.

Genus *Bifurculapes* E. Hitchcock

E. Hitchcock 1858, p. 152.

Lull 1915A, p. 57.

*Genotype: Bifurculapes laqueatus.**Generic Characters.*—Four regular rows of tracks which often unite at the base to resemble small forks—which suggests the name. Two additional rows of tracks are sometimes seen.

FIGURE 2.
Invertebrate trail,
Bifurculapes
laqueatus
Hitchcock.
Natural size.
After Hitchcock.

Bifurculapes laqueatus E. Hitchcock

E. Hitchcock 1858, p. 153, pl. 30, figs. 1-3.

Lull 1915A, p. 58, fig. 2.

Holotype, Cat. No. 36/33 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Pairs of tracks nearly opposite. Prongs sometimes united at their base but not often, outer prong of the fork frequently curved inward. Interval between the tracks never more than 2 mm. Width of the trackway, 6.5 mm.; length of the foot, 2 mm. Animal sometimes doubles on its course to form loops.*Bifurculapes elachistotatus* E. Hitchcock

E. Hitchcock 1858, p. 154, pl. 29, fig. 4, pl. 30, fig. 3.

Lull, 1915A, p. 58.

Holotype, Cat. No. 36/17 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—A very minute form as the name, signifying "less than the least," implies. The individual tracks are in two double rows, either small, straight dashes or reduced to dots, in slightly curved rows. The outer rows of tracks diverge slightly, the inner tracks are parallel with the line of progress. The feet of one side alternate with those of the other.*Bifurculapes tuberatus* E. Hitchcock

Species eliminated by Hitchcock in 1865, p. 15.

Bifurculapes curvatus E. Hitchcock

E. Hitchcock 1865, p. 15, pl. 7, figs. 2, 9.

Lull 1915A, p. 58.

Holotype, Cat. No. 55/62 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Track variable, toe marks decidedly curved, which distinguishes the tracks from those of the preceding species. The width of the trail is much the same.

Bifurculapes scolopendroideus E. Hitchcock

E. Hitchcock, 1858, pp. 153-154, pl. 27, fig. 1.

Lull 1915A, p. 58.

Holotype, Cat. No. 36/14 A. C. from Turners Falls, below the cataract.

Specific Characters.—This form is not at all typical of *Bifurculapes* for the outer rows of straight, divergent impressions are emphasized, the inner row, parallel with the line of progress, not always in evidence. If it is a true *Bifurculapes* it is by far the largest species.

Genus Lithographus E. Hitchcock

E. Hitchcock 1858, p. 156.

E. Hitchcock 1865, p. 15 (*Copeza*).

Lull 1915A, p. 58, fig. 3.

Genotype: *Lithographus hieroglyphicus*.

Generic Characters.—Tracks in three double rows. The longer inner tracks in parallel rows; the outer ones, crooked, sometimes even forked.

Lithographus hieroglyphicus

E. Hitchcock

E. Hitchcock 1858, p. 156, pl. 27, fig.

2, pl. 29, fig. 3.

E. Hitchcock 1865, p. 15 (*Copeza propinqua*).

Lull 1915A, p. 59.

Holotype, Cat. No. 36/26 A. C. from Field's Farm, Gill, Mass.

Specific Characters.—Longest tracks forming two almost continuous lines parallel to each other at a distance of 10 mm. Longest horn of the crooked track diverging away from the median line 30° to 40° . Shortest horn turning toward the median line. Length of the step 7 to 10 mm. Width of trackway, 20 mm.

Discussion. This is an instance of the re-naming of a genus and species by Hitchcock, but the name *Lithographus hieroglyphicus* 1858, having priority over *Copeza propinqua*, 1865, must stand.



FIGURE 3.

Lithographus hieroglyphicus
Hitchcock. Natural size.
After Hitchcock.

Lithographus cruscularis

E. Hitchcock

E. Hitchcock 1858, p. 157, pl. 29, fig. 4; pl. 30, fig. 3.

E. Hitchcock 1865, p. 15 (*Copeza cruscularis*).

Lull 1915A, p. 59.

Holotype, Cat. No. 36/17 A. C. also Nos. 36/18 and 36/35 from the Lily Pond, Gill, Mass.

Specific Characters.—A smaller, compactly complicated trail. The two inner rows small and nearly parallel, the outer crooked tracks arising opposite the inner tracks and diverging strongly outward. Length of the step about 4 mm. Width of the trackway 8 to 10 mm.

Lithographus punctatus (E. Hitchcock)

E. Hitchcock 1865, p. 15, pl. 6, figs. 14-15; pl. 18, fig. 1.
(Photograph) (*Copeza punctata*).

Lull 1915A, p. 59.

Holotype, Cat. No. 36/45 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Of this species, Hitchcock says: "All the impressions except the two principal rows are little more than mere punctures . . . hence the name. In size this trail is nearer that of *hieroglyphicus* than *cruscularis*."

Genus Copeza E. Hitchcock

E. Hitchcock 1858, p. 159.

Lull 1915A, p. 59.

Generic Characters.—Three rows of tracks on either side of the median line, the principal track at right angles to that line. The main distinction between this genus and *Lithographus* seems to be that in the latter the oblique markings are outside of the longitudinal whereas in *Copeza* they are within.

This seems to make the name *Copeza*, the oar-foot, inappropriate, for oars in use are always *outside* the boat.

Genotype: *Copeza triremis*, E. Hitchcock.

Copeza triremis E. Hitchcock

E. Hitchcock 1858, pp. 159-160, pl. 31, fig. 4.

Lull 1915A, p. 60, fig. 4.

Holotype, Cat. No. 36/37 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Those of the genus; and especially characterized by the extreme width of the trackway, 35 mm. as compared with the several species of *Lithographus*. (See Fig. 4.)

Genus Hexapodichnus

E. Hitchcock

E. Hitchcock 1858, p. 158.

Lull 1915A, p. 60.

Generic Characters.—Tracks arranged in triple rows on either

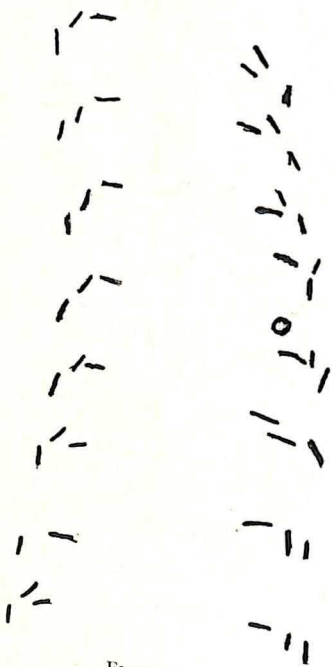


FIGURE 4.
Copeza triremis Hitchcock.
Natural size. After Hitchcock.

side of the median line, the inner tracks lying nearly parallel to that line. Outer tracks parallel or diverging outward, alternately on either side of the median line.

Genotype: Hexapodichnus magnus E. Hitchcock.

Hexapodichnus magnus E. Hitchcock

E. Hitchcock 1858, p. 158, pl. 29, fig. 7.

Lull 1915A, p. 60.

Holotype, Cat. No. 36/11 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Principal tracks by twos, alternating on either side of the median line. Third row of tracks small, irregularly placed and seldom seen.

Width of trackway, 20 mm.

Hexapodichnus horrens E. Hitchcock

E. Hitchcock 1858, pp. 158-159, pl. 30, fig. 1.

Lull 1915A, p. 60.

Holotype, Cat. No. 36/33 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Inner rows of tracks parallel with the median line; two outer rows diverging in differing degree so that they form a fork, the inner prong being the shorter.

Width of trackway, 14 mm.

Genus Conopsoides E. Hitchcock

E. Hitchcock 1858, p. 152.

Lull 1915A, p. 60.

Generic Characters.—"Tracks in three, and probably four rows, divergent from the median line. Foot [linear] blunt at its anterior part and so striking the mud in walking as to elevate a tubercle."

Genotype: Conopsoides larvalis E. Hitchcock.

Conopsoides larvalis E. Hitchcock

E. Hitchcock 1858, p. 152, pl. 29, fig. 6, pl. 30, fig. 4.

Lull 1915A, p. 61.

Holotype, Cat. No. 55/67 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Tracks straight, linear, in pairs on either side and divergent from the median line, the inner ones less divaricate than the outer ones. Sometimes part of a third row is present. Trail suggestive of that of *Hamipes didactylus*.

Conopsoides curtus E. Hitchcock

E. Hitchcock 1865, p. 15, pl. 6, fig. 4.

Lull 1915A, p. 61.

Holotype, Cat. No. 55/53 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Feet in four rows, short and sharply curved. A third intermediate row of small, straight marks sometimes appears on one side of the median line so that the total number of feet may have been six.

Genus *Harpepus* E. Hitchcock

E. Hitchcock 1865, p. 16.

Lull 1915A, p. 61.

Generic Characters.—"One, sometimes two, rows of tracks show a delicately curved foot, one end of which forms a raised and blunt extremity on the track. The resemblance to a sickle suggests the generic name."

Genotype: *Harpepus capillaris*, the only known species.

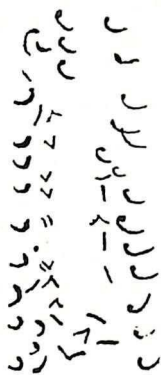


FIGURE 5.
Harpepus
capillaris
Hitchcock.
Natural size.
After Hitchcock.

Harpepus capillaris E. Hitchcock

E. Hitchcock 1865, p. 16, pl. 7, fig. 6.

Lull 1915A, p. 61, fig. 5.

Holotype, Cat. No. 55/99 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Those of the genus. The curve of the sickle hair-like, hence *capillaris*.

Genus *Sagittarius* E. Hitchcock

E. Hitchcock 1865, p. 16.

Lull 1915A, p. 61.

Generic Characters.—"Two rows of delicate curved tracks with their concave sides towards each other. Looking like so many small bows, which suggests the name."

Genotype: *Sagittarius alternans* E. Hitchcock.

Sagittarius alternans E. Hitchcock

E. Hitchcock, 1865, p. 16, pl. 6, fig. 2, pl. 18, fig. 5.

Lull 1915A, p. 61.
Holotype, Cat. No. 55/94 A. C. from the Lily Pond, Gill, Mass.
Specific Characters.—Those of the genus, with the bows alternating on the trail.

Phylum ARTHROPODA

INCERTÆ SEDIS

Genus *Lunula* E. Hitchcock

E. Hitchcock 1865, p. 17.

Lull 1915A, p. 61.

Generic Characters.—Two rows of lunate impressions extending laterally, one on either side of a narrow axis, appearing like the rachis of a plant with small lunate leaves.

Genotype: *Lunula obscura* E. Hitchcock.

Lunula obscura E. Hitchcock

E. Hitchcock, 1865, pp. 17-18, pl. 2, fig. 6.

Lull 1915A, p. 62.

Holotype, Cat. No. 52/12 A. C. from Turners Falls, Mass., on fine, red micaceous shale.

Specific Characters.—Those of the genus. "The anterior part of the foot makes a deeper impression than the posterior part which has no distinct outline but shades off into the subsequent track." Width of the trackway from 1 to 20 mm.

Genus *Pterichnus* E. Hitchcock

E. Hitchcock 1865, p. 17.

Lull 1915A, p. 62.

Generic Characters.—Two rows of tracks, usually quite numerous, diverging outward from the median line at an angle of 15° to 20° ; feather-like.

Genotype: *Pterichnus tardigradus* (E. Hitchcock).

Pterichnus tardigradus (E. Hitchcock)

E. Hitchcock (*Acanthichnus tardigradus*), 1858, p. 151, pl. 28, fig. 1.

E. Hitchcock 1865, p. 14, pl. 7, fig. 3 (*Pterichnus centipes*).

Lull 1915A, p. 62.

Holotype, Cat. No. 36/19 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Those of the genus. Length of the tracks, 3 mm. Width of the trackway, 12 mm.

Of *Pterichnus centipes* Hitchcock says: "In my Ichnology [1858], I have given a species of track under the name of *Acanthichnus tardigradus* . . . but which now seems more probably a Myriapod [than an insect]. I have therefore given it a new name *Pterichnus centipes* . . . taking it out of the genus *Acanthichnus*." The removal of this form from *Acanthichnus* seems justifiable but the original specific name *tardigradus* must stand.

Genus *Hamipes* E. Hitchcock

E. Hitchcock 1858, p. 150.

Lull 1915A, p. 62.

Generic Characters.—Tracks in pairs arranged in two parallel rows. Footprints curved inward so as to be somewhat hook-shaped.

Genotype: *Hamipes didactylus* E. Hitchcock.

Hamipes didactylus E. Hitchcock

E. Hitchcock 1858, p. 150, pl. 25, fig 8.

Lull 1915A, p. 61.

Holotype, Cat. No. 36/16 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Those of the genus. Large with a wide trackway of 40 mm. Axis of foot nearly parallel with the median line but generally at a slight angle outward.

Genus *Sphaeropus* E. Hitchcock

E. Hitchcock 1858, p. 164.

Lull 1915A, p. 63.

Generic Characters.—Trackway consisting of a furrow on the bottom of which are two rows of hemispherical impressions, as if made by tubercles rather than the feet of the animal.

Genotype: *Sphaeropus larvalis* E. Hitchcock.

***Sphaeropus larvalis* E. Hitchcock**

E. Hitchcock 1858, p. 164, pl. 28, fig. 2.

Lull 1915A, p. 64.

Holotype, Cat. No. 36/36 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Depressions small, nearly if not quite in contact. Width of the trackway, 5 mm.

***Sphaeropus magnus* E. Hitchcock**

E. Hitchcock 1858, p. 164, pl. 28, fig. 3.

Lull 1915A, p. 64.

Holotype, Cat. No. 10/6 A. C. from Field's orchard, Gill, Mass.

Specific Characters.—This species differs from *S. larvalis* chiefly in size and in the greater irregularity of the depressions. Width of the trackway, about 14 mm.

Genus *Grammepus* E. Hitchcock

E. Hitchcock 1858, p. 155.

Lull 1915A, p. 64.

Generic Characters.—"Tracks arranged in two parallel rows, the principal ones forming almost continuous lines, parallel to the line of direction. The two other tracks short, lying outside, and forming various angles with the median line."

Genotype: *Grammepus erismatus* E. Hitchcock.

***Grammepus erismatus* E. Hitchcock**

E. Hitchcock 1858, pp. 155-156, pl. 29, fig. 1.

Lull 1915A, p. 64.

Holotype, Cat. No. 36/39 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Those of the genus. Length of the longest track, 12 mm.; of the second, 7 mm., diverging from the first about 30°; the third, 5 mm. long, lying nearly at right angles with the line of direction; the two outer tracks seeming like buttresses to the others, and hence the specific name, from *erisma*, a buttress. Width of the trackway, 30 mm.

Genus *Ampelichnus* E. Hitchcock

E. Hitchcock, 1865, p. 19.

Lull 1915A, p. 65.

Generic Characters.—"Grooves rarely more than a quarter of an inch [6 mm.], sometimes half an inch [12 mm.] long", arranged somewhat in a rachis form. Most usually the grooves are in pairs. Of obscure origin and character.

Genotype: *Ampelichnus uniordinatus* (E. Hitchcock). E. Hitchcock 1865, p. 19, pl. 6, fig. 16 (*A. sulcatus*).

Holotype, Cat. No. 36/38 A.C. from the Lily Pond, Gill, Mass.

Specific Characters.—Those of the genus. Hitchcock says of this genus and species: "[*Grammichnus uniordinatus* of the Ichnology]. This genus is more obscure than the last [*Grammichnus*]. . . and the impression has the aspect of the stem and clusters of the grape; and hence the name [*ampelos*, a vine]." Not only was the species removed to his new genus, but a new species name "*sulcatus*" given to it as well. Of course the specific name *uniordinatus*, having priority, must stand.

Genus *Stratipes* E. Hitchcock

E. Hitchcock 1858, p. 149.

Lull 1915A, p. 65.

Generic Characters.—"Animal's feet perhaps didactylous; spread out in walking nearly at right angles to the line of direction."

Genotype: *Stratipes latus* E. Hitchcock.

Stratipes latus E. Hitchcock

E. Hitchcock 1858, p. 149, pl. 49, fig. 4.

Lull 1915A, p. 65, fig. 6.

Holotype, Cat. No. 13/4 A.C. from Field's orchard, Gill, Mass.

Specific Characters.—Those of the genus. "Toes somewhat curved and lying nearly parallel; length from 3 to 4 inches [75 to 100 mm.]. Distance between successive imprints of the same foot, 9 to 13 inches [228 to 328 mm.] which is the length of the step. . . . Width of the trackway, 27 inches [685 mm.]. . . . Hence the body of the animal may have been from 12 to 15 inches wide [304 to 383 mm.]."

Hitchcock goes on to say: "If this were not a giant crustacean I know not what he was and will not multiply words about him," and this seems to express the present state of our knowledge after nearly a century, for the idea of a giant crustacean does not fit into the present conception of time and environment.



FIGURE 6.
Stratipes latus Hitchcock. One-twentieth
natural size. After Hitchcock.

Genus *Saltator* E. Hitchcock

E. Hitchcock 1858, p. 137.

Lull 1915A, p. 66.

Generic Characters.—"Animals small; moving generally by leaps."

The two species united under this genus have little in common, except for the apparent method of progression, and may have been very different animals, but the evidence is insufficient to separate them.

Genotype: *Saltator bipedatus* E. Hitchcock.

***Saltator bipedatus* E. Hitchcock**

E. Hitchcock 1858, p. 137, pl. 25, fig. 8, pl. 51, fig. 7.
Lull 1915A, p. 66.

Holotype, Cat. No. 36/43 A. C. from below the dam at Turners Falls, Mass.

Specific Characters.—Digital impressions elongated ellipses, nearly opposite each other, and slightly divergent. Length of imprints about 12 mm. Length of leap, 32 mm., width of trackway 2 mm.

***Saltator caudatus* E. Hitchcock**

E. Hitchcock 1858, p. 138, pl. 24, figs. 9, 10.
Lull 1915A, p. 66.

Holotype, Cat. No. 9/9 A. C. from the Lily Pond, Gill, Mass.

Specific Characters.—Foot imprints small, rounded or somewhat elliptical dents in threes or fives with sometimes the imprint of what may have been a tail. Length of leap, 20 to 27 mm. Width of the trackway, 12 mm.

WORM-LIKE FORMS

Genus *Herpystezoum* E. Hitchcock

E. Hitchcock 1848, p. 245.

E. Hitchcock 1858, p. 160 (*Unisulcus*).
Lull 1915A, p. 66.

Generic Characters.—Trackway a continuous single groove. Straight, curved or looped.

Genotype: *Herpystezoum marshii* E. Hitchcock.

***Herpystezoum marshii* E. Hitchcock**

E. Hitchcock 1848, p. 246, pl. 17, fig. 1.

E. Hitchcock 1858, p. 160, pl. 26, fig. 1, pl. 49, fig. 1 (*Unisulcus marshii*).
Lull 1915A, p. 67.

Holotype, Cat. No. 19/11 A. C. from the Ferry, Turners Falls, Mass.

Specific Characters.—Single groove 6 mm. wide, not infrequently looped. This species is also found at Portland, Conn.

***Herpystezoum minutum* E. Hitchcock**

E. Hitchcock 1848, p. 246, pl. 17, fig. 2.

E. Hitchcock 1858, p. 161, pl. 26, fig. 3 (*Unisulcus minutus*).
Lull 1915A, p. 67.

Holotype, Cat. No. 36/22 A. C. from Turners Falls, Mass.

Specific Characters.—Very narrow groove, 1 mm. wide. Trackways very numerous and intermingled.

***Herpystezoum intermedius* (E. Hitchcock)**

E. Hitchcock 1858, p. 161, pl. 26, fig. 2 (*Unisulcus*).

Lull 1915A, p. 67.

Holotype, Cat. No. 36/22 A. C. from the Horse Race, Gill, Mass.

Specific Characters.—Groove much curved and often looped. Width of the groove, 2 mm.

***Herpystezoum magnum* (C. H. Hitchcock)**

C. H. Hitchcock 1889, pp. 119, 122 (*Unisulcus*).

Lull 1915A, p. 67.

Holotype in Lafayette Collection from Smith Clark's Quarry, Milford, N. J.

Specific Description.—No description or figure has been published. The species is therefore a *nomen nudum*.

Genus *Halysichnus* E. Hitchcock

E. Hitchcock 1858, p. 162.

Lull 1915A, p. 67.

Generic Characters.—"Trackway with ridges on each side; as if the animal had ploughed its way through the mud instead of gliding over the surface; crossed at intervals by depressions giving the pathway the appearance of a chain."

Genotype: Halysichnus laqueatus E. Hitchcock.

***Halysichnus laqueatus* E. Hitchcock**

E. Hitchcock 1858, p. 163, pl. 26, fig. 7.

Lull 1915A, p. 67.

Cotypes, Cat. Nos. 33/35, 52/11 A. C. from Turners Falls, Mass.

Specific Characters.—Length of the links of the trackway 7 mm. to 17.5 mm. Links slightly widened in the middle. Pathway repeatedly looped as the name implies.

***Halysichnus tardigradus* E. Hitchcock**

E. Hitchcock 1858, p. 163, pl. 26, fig. 8.

Lull 1915A, p. 67.

Holotype, Cat. No. ? in Mr. Field's collection from Fields Farm, Gill, Mass.

Specific Characters.—Trackway resembles a loose string of beads from the bead-like character of the links. Length of the links, 4 to 6 mm. Trail frequently looped.

Genus *Cunicularius* E. Hitchcock

E. Hitchcock 1858, p. 163.

Lull 1915A, p. 67.

Generic Description.—A covered pathway along the surface. The arch formed of bits of the sediment.

Genotype: Cunicularius retrahens E. Hitchcock.

Cunicularius retrahens E. Hitchcock

E. Hitchcock 1858, p. 163, pl. 26, fig. 4.

Lull 1915A, p. 67.

Holotype, Cat. No. 33/36 A.C. from Turners Falls below the cataract, Mass.

Specific Characters.—Trackway crooked and branched, terminating abruptly, sometimes showing an accumulation of mud at the end. Animal able to move forward or backward. Width of the furrow, 6 to 10 mm.

Occurs also at Middletown, Conn.

Genus *Cochlea* E. Hitchcock

E. Hitchcock 1858, p. 162.

Lull 1915A, p. 68.

Generic Characters.—"Trackway somewhat resembling a double screw or spiral."

Genotype: *Cochlea archimedeia*.



FIGURE 7.
Cochlea archimedeia
Hitchcock. Two-thirds natural size.
After Hitchcock.

Cochlea archimedeia E. Hitchcock

E. Hitchcock 1858, p. 162, pl. 26, fig. 9, pl. 49, fig. 7.

Lull 1915A, p. 68, fig. 7.

Holotype, Cat. No. 36/49 A.C. from the Lily Pond, Gill, Mass.

Specific Characters.—Trackway somewhat resembling an Archimedean screw. Sometimes branching. Width of the groove 5 mm. Width of the whole surface covered by the furrow, 18 mm. Distance from curve to curve on the same side, 18 mm.

Genus *Cochlichnus* E. Hitchcock

E. Hitchcock 1858, p. 161.

Lull 1915A, p. 68.

Generic Description.—"Trackway a continuous serpentine furrow, resembling a compressed corkscrew."

Genotype: *Cochlichnus anguineus* E. Hitchcock.

Cochlichnus anguineus E. Hitchcock

E. Hitchcock 1858, p. 161, pl. 26, fig. 6, pl. 37, fig. 4.

Lull 1915A, p. 68.

Holotype, Cat. No. 36/20 A.C. from the Lily Pond, Gill, Mass.

Specific Characters.—Trackway a groove of reversed curvatures. "Chord of the right and left curvatures, 0.3 to 0.75 inch [7 to 18 mm.]. Width of the trackway about the thirtieth of an inch [1 mm.], broader in that part of the curve against which the animal pressed

the hardest in advancing like a snake; which must have been its mode of progression. Spire not infrequently gradually diminishing towards one extremity" (Hitchcock).

C. H. Hitchcock 1889, p. 122, speaks of two species of *Cochlichnus* from the Wethersfield cove, Conn., without naming or defining them.

Genus *Bisulcus* E. Hitchcock

E. Hitchcock 1865, p. 18.

Lull 1915A, p. 69.

Generic Characters.—Continuous, paired grooves separated by a single ridge.

Genotype: *Bisulcus undulatus* E. Hitchcock.

Bisulcus undulatus E. Hitchcock

E. Hitchcock 1865, p. 18, pl. 3, fig. 5.

Lull 1915A, p. 69.

Holotype, Cat. No. 10/6 A. C. from Field's orchard, Gill, Mass.

Specific Characters.—Those of the genus. Serpentine course, "looking like sections of waves."

Genus *Trisulcus* E. Hitchcock

E. Hitchcock 1865, p. 18.

Lull 1915A, p. 69.

Generic Characters.—Three continuous grooves separated by intermediate ridges, which sometimes show slight protuberances like those of *Sphaeropus*.

Genotype: *Trisulcus laqueatus* E. Hitchcock.

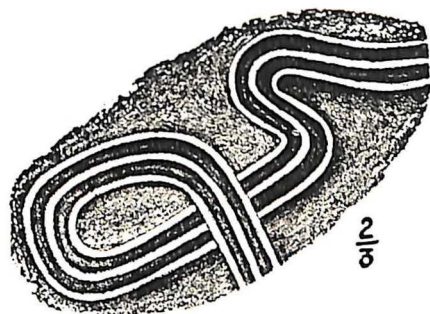


FIGURE 8.

Trisulcus laqueatus Hitchcock. Two-thirds natural size. After Hitchcock.

Trisulcus laqueatus E. Hitchcock

E. Hitchcock 1865, pp. 18-19, pl. 3, fig. 4.

Lull 1915A, p. 69, fig. 8.

Holotype, Cat. No. 52/12 A. C. from Turners Falls, Mass.

Specific Characters.—Those of the genus. The animal sometimes turned back and crossed its own trail so as to form graceful loops. Impressions of doubtful origin and character.

Genus *Harpagopus* E. Hitchcock

E. Hitchcock, 1848, p. 247.

Lull 1915A, p. 69.

Generic Characters.—A succession of obliquely placed impressions more or less elliptical in form, of very doubtful character. C. H. Hitchcock 1889, p. 110, classes them with "Inferior Arthropods, etc."

Three species are mentioned in the original description: *Harpagopus giganteus* (p. 247) from the Connecticut valley, *H. hudsonius* (p. 248) from the Hamilton group, Middle Devonian, of New York, and *H. dubius* (p. 249) from the Connecticut valley. Of these only *H. dubius* is mentioned by C. H. Hitchcock in his 1889 list.

Genotype: *Harpagopus dubius* E. Hitchcock.

Harpagopus dubius E. Hitchcock

E. Hitchcock 1848, p. 249, pl. 18, fig. 3.

Lull 1915A, p. 69.

Cotypes, Cat. Nos. 32/9 and 32/46 A. C., the former specimen from Turners Falls, the latter from the South Hadley Canal.

Specific Characters.—Those of the genus.

Genus *Grammichnus* E. Hitchcock

E. Hitchcock 1865, p. 19.

Lull 1915A, p. 70.

Generic Characters.—Single series of elongate impressions, repeated serially, and placed at various angles.

Genotype: *Grammichnus alpha*.

Grammichnus alpha E. Hitchcock

E. Hitchcock 1865, p. 19, pl. 3, fig. 4.

Lull 1915A, p. 70.

Holotype, Cat. No. 47/13 A. C. Locality unrecorded.

Specific Characters.—Those of the genus. "There is no clue to the nature of the animal or certainty that it is not of vegetable origin" (E. Hitchcock).

Genus *Climacodichnus* E. Hitchcock

E. Hitchcock 1865, p. 20.

Lull 1915A, p. 70.

Generic Characters.—"Small ladder-like rows of impressions, a good deal resembling the steps of *Acanthichnus*, but more than sufficient to form the sides of the ladder, and extending past one another."

Genotype: *Climacodichnus corrugatus* E. Hitchcock.

Climacodichnus corrugatus E. Hitchcock

E. Hitchcock 1865, p. 20, pl. 7, fig. 5, pl. 13.

Lull 1915A, p. 70.

Holotype, Cat. No. 33/57 A. C. from Turners Falls, Mass.

Specific Characters.—Those of the genus. Width of the trackway or ladder, about 14 mm. Length of the individual tracks not usually much more than 5 mm.

Genus AEnigmichnus E. Hitchcock

E. Hitchcock 1865, pp. 20, 21.

Lull 1915A, p. 70.

Judging from the photographs figured by Hitchcock (1865, pl. 14.) and a specimen in the Yale Museum which is apparently a portion of the type, this genus seems to be not of animal origin, but rather the result of the rolling over and over of a tree top or other floating vegetation, rhythmically repeated, resulting in a series of parallel rows of lines, grooves, and depressions which Hitchcock has laboriously classified and described.

AEnigmichnus multiformis E. Hitchcock

E. Hitchcock 1865, pp. 20-21, pl. 1, figs. 4, 5, pl. 11, figs. 1-6, pl. 12, figs. 1-4, pl. 14.

Locality.—Ferry above Turners Falls; ferry at Turners Falls.

THE VERTEBRATES**THE AQUATIC VERTEBRATES**

Among the vertebrate fossils found in the Newark rocks of the Connecticut valley, two classes, fishes and reptiles, are represented by actual osseous remains; the latter surely, and probably the amphibia, are represented by their footprints. Whether or not the two higher classes, the birds and mammals, are represented is not yet proven. No mammalian remains are known from the Newark system, and the first authentic avian relics, those of *Archaeopteryx*, and *Archaeornis*, already a long way along the road to avian perfection, coming as they do from the Upper Jurassic, would surely imply birds in some stage in their evolution during Newark time. The fishes have been studied exhaustively by Doctor C. R. Eastman for the Connecticut Geological and Natural History Survey¹, but in order to make my review of the Connecticut valley Triassic life complete I will insert the list of genera and species contained in Doctor Eastman's work.

The fish remains are almost entirely from the two general levels of black bituminous shale which also contain the plant relics, already enumerated, in varying profusion. Rarely are footprints found in juxtaposition to the fishes, and never, so far as I am aware, upon fish-bearing shales themselves.

Geologically the shale bands are associated with the trap out-flows, a lower bed following 50 to 100 feet above the lower trap sheet, and

¹Eastman, C. R., 1911.

an upper bed occurring about 100 feet below the upper trap, the relationship of the shale and trap being in the one case the reverse of the other.

Geographically the fish localities are distributed from Turners Falls, Massachusetts, to Lake Saltonstall at New Haven, Connecticut, the principal localities for the lower zone being:

Durham (west slope of Totoket), Connecticut.
Bluff Head, Connecticut.
Higby, Connecticut.
Berlin, Connecticut.
Southington, Connecticut.
? Southbury, Connecticut.

For the upper zone:

Turners Falls, Massachusetts.
Sunderland, Massachusetts.
Chicopee Falls, Massachusetts.
Lake Saltonstall, Connecticut.
Durham (east of Pistapaug mountain), Connecticut.
Westfield, Connecticut.
South Bloomfield, Connecticut.
North Bloomfield, 1 mile east of Tariffville, Connecticut.
Rocky Hill, Hartford, Connecticut.

Besides these localities there is one in Middlefield, near the Laurel Brook Reservoir, which belongs to a horizon above the upper trap sheet. One or two other localities of fossiliferous black shale have been reported, but are doubtful.

Of these localities by far the most important are Sunderland, Durham, and, of those without the limits of the valley, Boonton, New Jersey.

List of Species

Slightly modified from Eastman (1911)

Class **PISCES**

Subclass **Teleostomi**

Order **Crossopterygii**

Family **CELACANTHIDÆ**

Genus **Diplurus** Newberry

Diplurus longicaudatus Newberry

Localities.—Durham, Conn.; Boonton, N. J.

Order **Actinopterygii**

Suborder **Chondrostei**

Family **CATOPTERIDÆ**

Genus **Catopterus** J. H. Redfield

Catopterus gracilis J. H. Redfield

Localities.—Middletown, Middlefield, Durham, Southbury, Conn.; Sunderland, Mass.; Boonton, N. J.

Catopterus redfieldi Egerton

Localities.—Durham, Conn.: "apparently at other localities in the Connecticut valley and in New Jersey" (Newberry).

Genus *Dictyopyge* Egerton

Dictyopyge macrura W. C. Redfield

Locality.—Middletown, Conn.

Suborder *Protospondyli*

Family *SEMIONOTIDÆ*

Genus *Acentrophorus* Traquair
(Generic position uncertain)

Acentrophorus chicopensis Newberry

Localities.—Chicopee Falls, Mass.; and, according to Hay, from New Jersey and Connecticut.

Genus *Semionotus* Agassiz

Palæoniscus (in part) and *Ischypterus* Egerton

Semionotus agassizii (W. C. Redfield)

Localities.—Sunderland, Mass.; Westfield and Middlefield, Conn.; Pompton and Boonton, N. J.

Semionotus alatus (Newberry)

Locality.—Boonton, N. J.

Semionotus braunii (Newberry)

Locality.—Weehawken, N. J., beneath the trap of the Palisades.

Semionotus elegans (Newberry)

Locality.—Boonton, N. J.

Semionotus fultus (Agassiz)

S. macropterus (W. C. Redfield), according to Hay.

Localities.—Boonton, N. J.; Sunderland, Mass.; and Durham, Connecticut.

Semionotus gigas (Newberry)
(Provisional species)

Locality.—Boonton, N. J.

Semionotus lenticularis (Newberry)

Locality.—Boonton, N. J.

Semionotus lineatus (Newberry)

Locality.—Boonton, N. J.

Semionotus micropterus (Newberry)

Locality.—Durham, Conn.

Semionotus minutus (Newberry)
(Doubtful species)

Locality.—Durham, Conn.

Semionotus modestus (Newberry)

Locality.—Boonton, N. J.

Semionotus ovatus (W. C. Redfield)

Localities.—Turners Falls and Sunderland, Mass.; Westfield and Middlefield, Conn.; and Boonton, N. J.

Semionotus parvus (W. C. Redfield)
(Doubtful species)

Localities.—Sunderland, Mass.; perhaps Durham and Westfield, Conn.; Boonton, N. J.

Semionotus tenuiceps (Agassiz)

S. latus (J. H. Redfield) according to Hay.

Localities.—For specimens described as *S. latus*—Sunderland, Mass.; Westfield, Middlefield and Durham, Conn.; and Pompton, Boonton and Plainfield, N. J.

Family EUGNATHIDÆ

Genus *Ptycholepis* Agassiz

Ptycholepis marshi Newberry

Locality.—Durham, Conn.

We have therefore six genera and twenty species, of which six genera and thirteen species are found within the limits of the Connecticut valley, and six genera and probably thirteen species in the state of Connecticut, while New Jersey has produced four genera and sixteen species.

THE TERRESTRIAL VERTEBRATES

GENERAL DESCRIPTION

SKELETAL REMAINS

While the footprints constitute by far the great bulk of our evidence concerning terrestrial life of Newark time, the actual bone remains are more numerous than is generally supposed, though the majority of the finds have been of the most meagre description. W. M. Davis as late as 1898 (p. 35) speaks thus of the bone discoveries:

"The skeletons of these ruling inhabitants are exceedingly rare, only one having yet been discovered in Connecticut, but this, accidentally found in the abutment of a bridge at Manchester, is so well preserved that it excites the hope of finding more."

Davis refers to the story of the discovery of the type of *Ammosaurus* major Marsh, now preserved in the Yale Museum, which will be detailed below (*vide infra* p. 61.).

Emerson and Loomis in 1904 (p. 377) in speaking of the discovery of *Stegomosuchus* (*Stegomus*) *longipes* say:

"The number of osseous remains [of the Connecticut valley] is limited to three dinosaur specimens and a portion of an *Aëtosaurus*-like carapace, called by Marsh, *Stegomus*."

As a matter of fact no fewer than three genera and five species of dinosaurs, one species of phytosaur and two species of Pseudosuchians are known, making four genera and seven species, including that which Emerson and Loomis were describing at the time of their writing, while the actual number of bone remains from the Connecticut valley exceeds this record of different forms.

The northernmost locality where bones have been found is Greenfield, Mass., where a bone fragment presumably dinosaurian was discovered in 1875 (?) by Solon Wiley in a red sandstone quarry about one-half mile north of the village. This specimen was preserved in the Yale Museum.

The next locality to the south is at South Hadley, Mass., "in a boulder of Triassic sandstone which the glacier carried two or three miles, possibly, and deposited not far from the site of Mount Holyoke College" (Talbot 1911, p. 469). This discovery was made by Miss Mignon Talbot in 1910.¹ Moreover in the *Proceedings of the Boston Society of Natural History*, vol. iii, p. 340, 1850, mention is made of large vertebrates from East Windsor and South Hadley. Those from the former locality are discussed below; of the latter I can find no further trace either in the literature or in known collections unless "a few very imperfect fragments of the bones of a similar species [to *Thecodontosaurus* (*Megadactylus*) *polyzelus*] which were found earlier and are preserved in the museum" at Amherst, referred to by Emerson (*loc. cit.*), constitute the material alluded to. Material if I mistake not is also preserved in the Boston Society's Museum.

At Belchertown, Mass., Emerson (1898 A, p. 406) has "found many imperfect fragments of bone in the indurated sandstone of the contact zone of the easternmost volcanic core. . . . This induration has prevented the percolation of water, which has doubtless carried away many bones formerly embedded in these coarse sandstones."

The next locality is at Springfield, Mass., where before the Civil War (1856?) "the bones were thrown out by a blast in excavating a well for the casting of a big gun at the water shops of the United States Armory, in the south part of Springfield, and only a part of the skeleton was preserved and presented to President Hitchcock" (Emerson 1898 A, p. 405).

The most southerly Massachusetts locality known to me is at Longmeadow. Emerson and Loomis (1904, p. 377) thus describe the discovery of this fossil:

¹The specimen (*Podokesaurus*) was preserved in the museum of Mount Holyoke College until it was lost in the destruction of the building by fire in 1900. A cast of this specimen colored by Lull from the original is in the Yale Peabody Museum.

"Some seven years ago, while removing the superficial layers of sandstone in the Hines Quarry, which is about a mile east of the village of East Longmeadow, Mass., Mr. G. B. Robinson found the small lizard-like specimen which is the subject of this paper. It occurred in a dense layer of red sandstone some ten feet below the surface and immediately above the thicker and softer layers which are used commercially for building stone. The discoverer removed the blocks containing the animal to his door yard, where they remained for about seven years exposed to the weather. They were seen by Mr. and Mrs. E. D. White, who obtained possession of them and brought the fossil to Springfield. Mr. and Mrs. White kindly placed this finely preserved fossil at our disposal for study and description." This specimen is deposited in the Museum at Amherst College.

In Connecticut the northernmost locality is that of East Windsor, the specimen now preserved at Yale having the distinction of being the first Triassic fossil found in the Connecticut valley the discovery of which is recorded. This find was made over a century ago, in 1818, and the first notice is contained in the *American Journal of Science*, vol. ii, 1820. Nathan Smith (1820, p. 146) thus described the discovery:

"Mr. Solomon Ellsworth, Jun., of East Windsor (Conn.), has politely favoured me with some specimens of fossil bones, included in red sand stone. Mr. Ellsworth informs me that they were discovered by blasting in a rock for a well; they were 23 feet below the surface of the earth, and 18 feet below the top of the rock. Unfortunately, before Mr. Ellsworth came to the knowledge of what was going on, the skeleton had been blown to pieces, with the rock which contained it, and several pieces of bones had been picked up, and then lost. . . . Mr. Ellsworth states that the bones were found in a horizontal position across the bottom of the well, as he thinks nearly to the extent of six feet."

This specimen, Cat. No. 2125 of the Fossil Vertebrate collection at the Yale Peabody Museum, I have identified as *Yaleosaurus* (*Anchisaurus*) *colurus* (Marsh) (*vide infra* p. 107).

Still another locality is that of Ellington, Conn., from which material was described and figured by E. Hitchcock in his "Final Report on the Geology of Massachusetts," 1841, pp. 503-504. The description of the discovery is as follows:

"Still more remarkable specimens, for which I am also indebted to Prof. Silliman, are shown on Plate 46, Figs. 69-73, of the natural size. These are made up entirely of fine reddish sand; and yet, their resemblance to bones is too obvious to be mistaken. . . .

"These specimens were presented to Professor Silliman by a son of Hon. John Hall, of Ellington; a town that adjoins East Windsor. In answer to my enquiries, Judge Hall informs me, by letter, that the specimens were found at two places in Ellington; neither of which is more than $2\frac{1}{2}$ miles from the locality already described in East Windsor."

These relics were at best only the casts of bones formed by the infiltration of sand into the place where bones had lain. It has not been possible to trace them if indeed they exist to-day, but they seem to have been of dinosaurian origin.

By far the most notable bone locality in the valley is at Manchester, the place of origin of the important type specimens of *Yaleosaurus* (*Anchisaurus*) *colurus*, *Anchisaurus solus* and *Ammosaurus major*, all of which, described by Professor Marsh, are preserved in the Peabody Museum at Yale. From Professor Marsh's notes the following is extracted:

These specimens were found in the quarry of Mr. Charles O. Wolcott about one mile north of Buckland station in a layer about two and one-half feet in thickness, and, as the quarry was then worked, somewhat above the level of the roadway.

The first specimen, the *Ammosaurus major*, was found in 1884, and before its value was recognized the rock containing the skull and fore quarters was built into the abutments of a bridge over Bigelow brook, South Manchester. When the block containing the hind quarters was taken out, it was saved by Mr. Wolcott, and news of its discovery sent to Professor Marsh by Charles H. Owen, of Buckland, by whose aid and that of T. A. Bostwick the specimen was purchased. Subsequent earnest effort failed to secure the anterior portion.

The second saurian, *Yaleosaurus* (*Anchisaurus*) *colurus*, was found in the same layer, twenty feet south, in a large block of sandstone. The portion exposed showed the scapula and humerus and this had been the outer surface of the quarry for a long time. There was no record of when the adjoining block had been removed. Part of the large block was split off at New Haven, and this smaller piece contained the head and part of the neck. The rest of the skeleton (except one fore leg, one hind leg, the ends of the ischia, and the tail) was subsequently found in the main block.

The third saurian, *Anchisaurus solus*, was found at the same time as the second, in two small blocks which were subsequently fitted together. It was about two feet higher than, and about fifteen feet southeast of the previous specimen. This third specimen is nearly entire.

Saurian No. 4. During a visit to this quarry, September 24, 1894, three and a half years after the other specimens were received at New Haven, Professor Marsh found in essentially the same layer a large rib, quite perfect, and probably pertaining to an animal somewhat larger than any of the above. There is unfortunately no record of the receipt of this rib at New Haven.

On the west side of the valley and therefore, owing to the eastern dip of the Triassic strata, at a much lower geological level, another locality was discovered in the town of Simsbury. This specimen, consisting of a single bone, was found in the quarry of Orestes Wilcox, half a mile southwest from the station at Simsbury. It was designated

as the type specimen of *Clepsysaurus* (*Belodon*) *validus* by Marsh (*vide infra* p. 89), and was received in the Yale Museum November 19, 1888.

The last locality in the valley is at Fair Haven, actually within the limits of the municipality of New Haven. The specimen was found in the quarry of Freeman Clark, not far from the Ferry Street bridge over the Quinnipiac river, and consists of the impression of the dorsal armor plates with no trace of actual bone. The specimen constitutes the type of *Stegomus arcuatus* Marsh and is preserved in the Yale Museum.

Thus it will be seen that at least eleven authentic localities in the Connecticut valley have produced vertebrate remains other than foot-prints, eight of the remains apparently of dinosaurs and three unquestionably of other reptiles (pseudosuchians); of these nine are from near the summit of the Newark series geologically, while two, that of Simsbury and that of Fair Haven, are below the extrusive trap and therefore at a very much lower level. The dinosaurs and *Stegomus* (*Stegomus*) *longipes* are from the newer, the *Clepsysaurus* and *Stegomus arcuatus* from the older rocks (New Haven arkose).

New Jersey has thus far been less prolific of actual bone from the Newark system though much material of later age has been brought to light. The Yale Museum contains a specimen of a phytosaur of undetermined species from the Belleville quarry just north of the city of Belleville (Edwards, *Amer. Jour. Sci.*, (3) 1, 1895, p. 346). This specimen, consisting as it does of a portion of a jaw without teeth, was said by Edwards to "look like *Dromatherium sylvestre* of Emmons." It is quite evident that Edwards never saw the minute jaw of the animal *Dromatherium* or he would never have made such a comparison. Another fragment of bone from the sandstone quarries at Belleville, "too imperfect for identification," is preserved in the museum at Columbia University.

The public press of 1910, notably the *New York Tribune* of December 22d, announced the discovery of a "dinosaur" on the west shore of the Hudson at Fort Lee, New Jersey, below the Palisades. This animal was described by V. Huene as a phytosaur, *Rutiodon manhattanensis*, now *Clepsysaurus*. It is preserved in the American Museum of Natural History (see Plate III). More material of nearly equivalent age came from the Brunswick formation in Clinton and near the border between Clinton and Passaic, New Jersey. The first was described by Gilmore in 1928 as *Hypsognathus fenneri* and the later specimens by Colbert in 1946. The type is in the U. S. National Museum and the later material in the American Museum (see p. 94). *Hypsognathus* proves to be a cotylosaurian reptile more or less equivalent in age to *Stegomus arcuatus* of the New Haven arkose.

An abundance of material has been obtained from Upper Millford and Phoenixville, Pennsylvania, from which several species have been described as dinosaurs. Their reference to that order is not admitted by Huene (1906, p. 101), but the whole material, the bulk of which is now in the Cope collection at the American Museum, should be

restudied before final judgment is passed. It is my impression, however, that the Pennsylvania localities represent an older faunal phase than the dinosaurs of the Connecticut valley. The characters of the matrix (Wheatley 1861) and the associated fossils point to very different environmental conditions from those of the New England and New Jersey areas, hence a discussion of the fruits of the Pennsylvania locality may very properly be postponed.

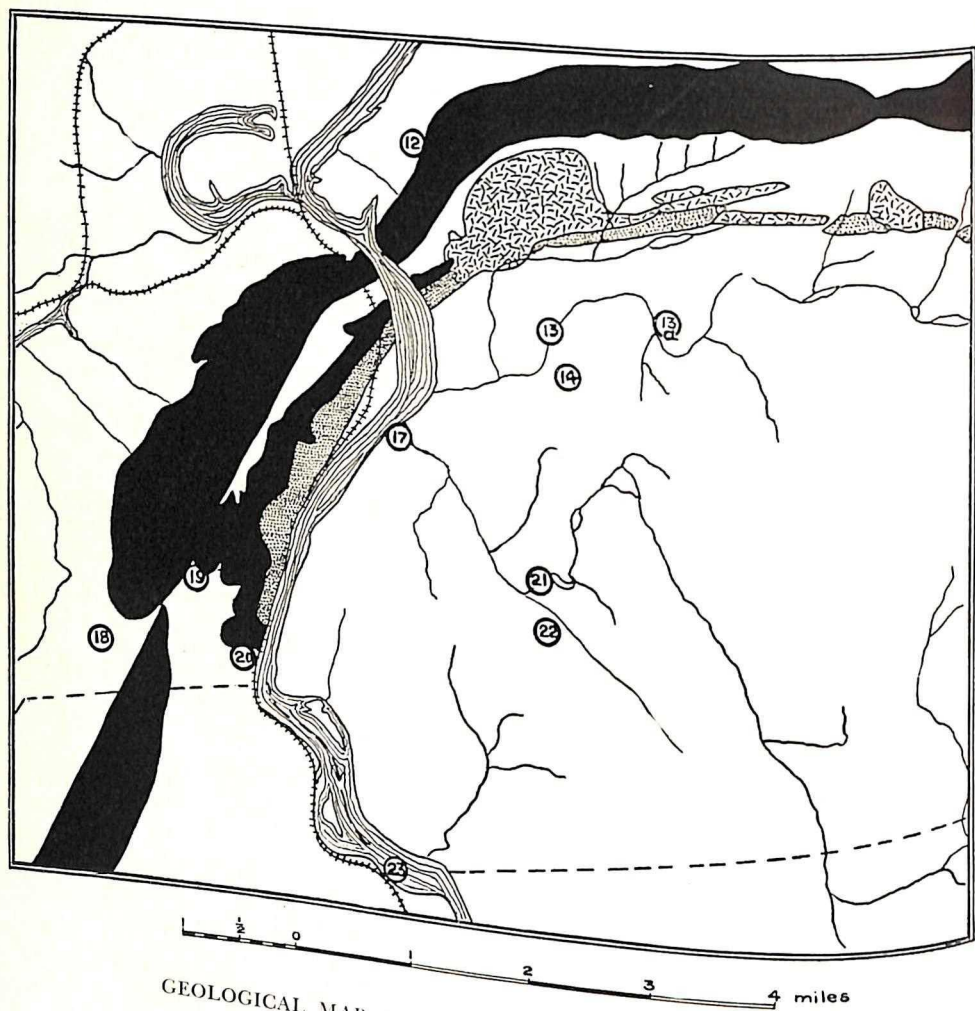
FOOTPRINTS

While fossil footprints vastly exceed in numbers and kinds the actual bones, they like the latter are confined to certain definite geological levels, so that, while evidence of an abundant fauna is given, it is for the most part a contemporaneous fauna confined to the closing act of the Newark drama.

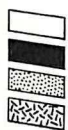
Bone and Footprint Localities (indicated by numbers on the maps)

Massachusetts

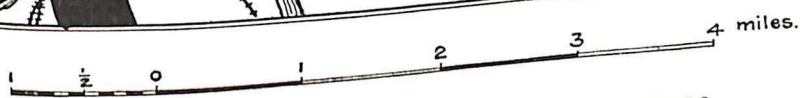
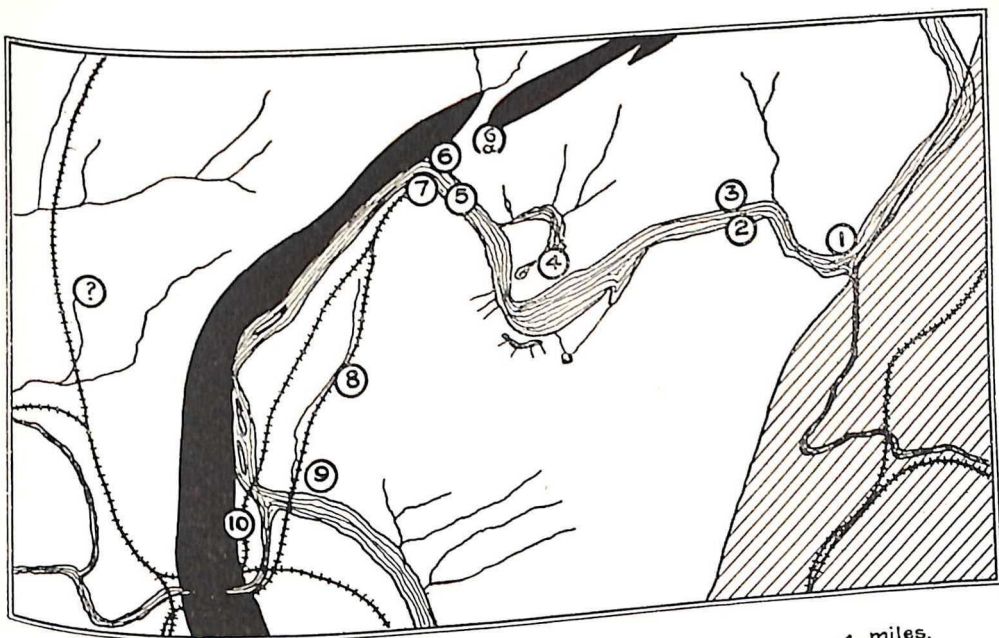
1. North bank of Connecticut River, nearly opposite mouth of Millers River
- 2, 3. Horse Race
4. Lily Pond
5. Ferry above Turners Falls
6. North bank below Turners Falls
- 6a. Orchard, Gill
7. Montague Canal
8. Montague City
9. Marsh's Quarry, Montague
10. Greenfield
- ? Greenfield? bone locality
11. Belchertown bone locality
12. Mt. Holyoke
13. Stream near Pliny Moody's
- 13a. Moody's Corner
14. Dickinson's Quarry, South Hadley
17. South Hadley, opposite Smith's Ferry
18. Mt. Tom, west
19. Mt. Tom, east
20. Below Smith's Ferry
21. South Hadley
22. South Hadley, *Podokesaurus* locality
23. Holyoke Dam
24. Holyoke
25. Chicopee Falls
26. Chicopee, near "Cabotville"
27. Springfield water shops, *Anchisaurus polyzelus* locality
28. Longmeadow, *Stegomosuchus* (*Stegomus*) *longipes* locality



GEOLOGICAL MAP OF VICINITY OF SOUTH HADLEY.



- Triassic Sedimentary Rocks.
- Contemporaneous Sheets of Trap.
- Tufa and Agglomerate.
- Volcanic Cores, and Dikes of Trap.



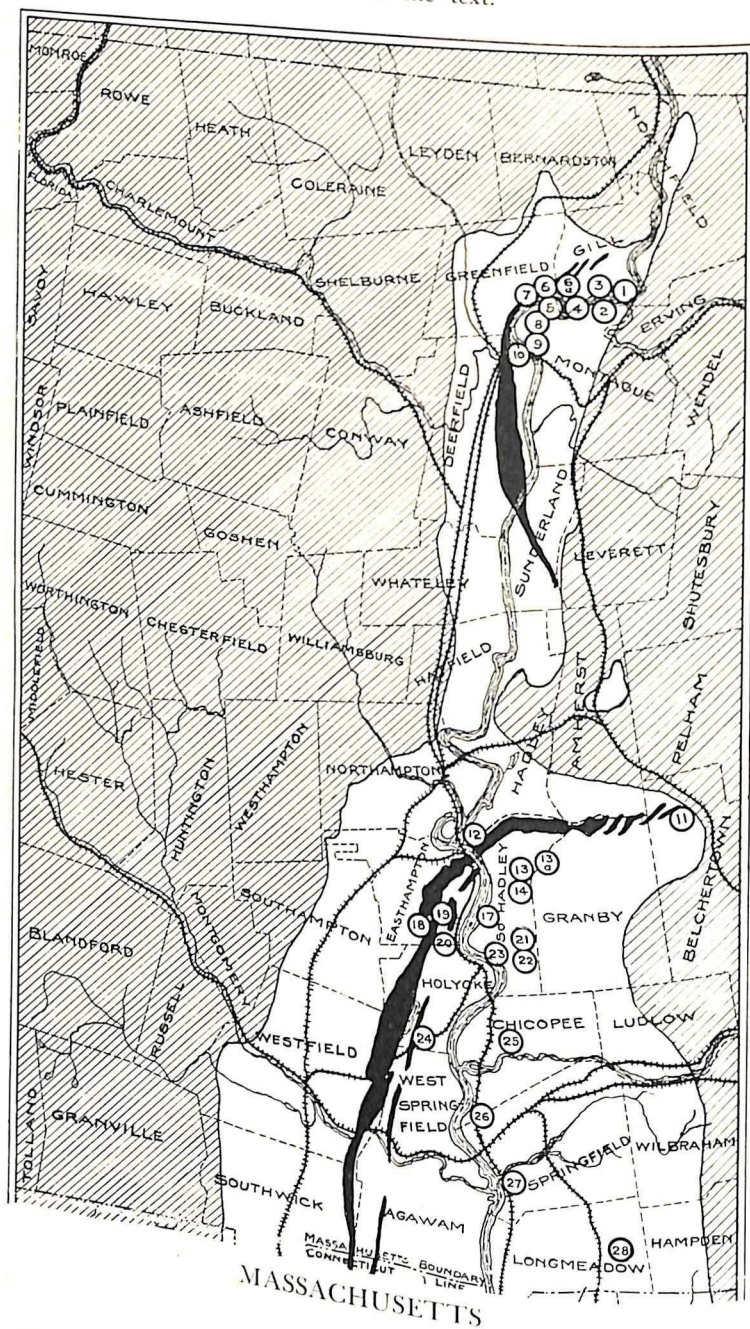
GEOLOGICAL MAP OF VICINITY OF TURNERS FALLS

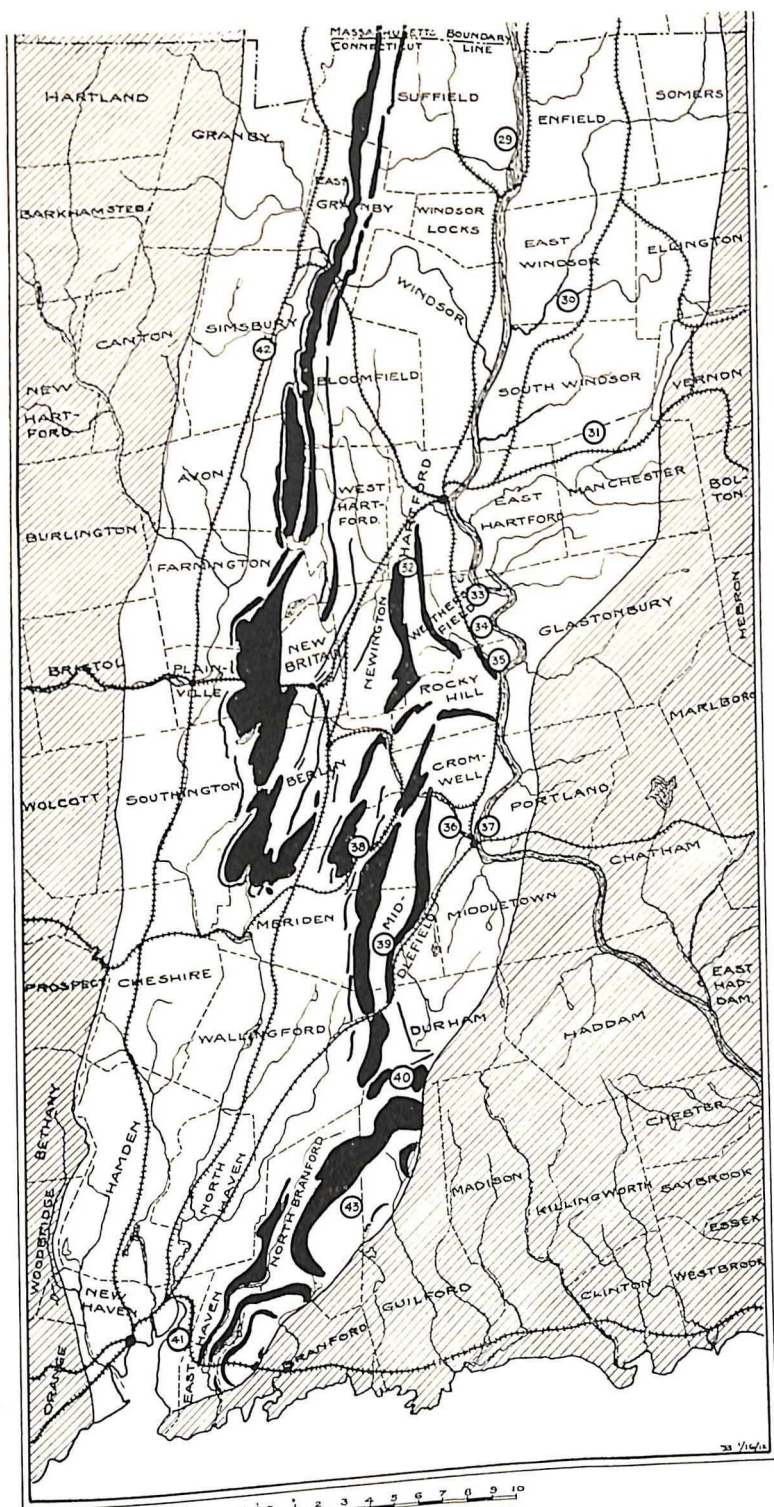
-  Pre-Triassic Crystalline Rocks.
-  Triassic Sedimentary Rocks.
-  Contemporaneous Sheet of Trap.

GEOLOGICAL MAP OF CONNECTICUT VALLEY TRIASSIC
AREA, SHOWING THE KNOWN LOCALITIES OF
FOSSIL FOOTPRINTS AND FOSSIL BONES.

-  Pre-Triassic Crystalline Rocks.
-  Triassic Sedimentary Rocks.
-  Contemporaneous Sheets of Trap.

The numbers within the circles indicate the localities referred to in the text.





Connecticut

29. Suffield
30. Ketch's Mills, East Windsor, bone locality
31. Manchester, *Anchisaurus* and *Ammosaurus* locality
32. "Rocky Hill," Hartford
33. Wethersfield Cove
- 34, 35. Wethersfield
36. Middletown
37. Portland
38. Higby
39. Middlefield
- 40? Durham
41. New Haven, *Stegomus arcuatus* locality
42. Simsbury, *Clepsysaurus* (*Rutiodon*) *validus* locality
43. North Branford

Geographical Distribution

Geographically the tracks are distributed from Turners Falls to New Haven—nearly the entire length of the valley; but the greatest abundance of localities and the greatest profusion both of species and specimens are in the northern portion of the area, specifically around Turners Falls, and near South Hadley, Massachusetts.

Hitchcock in the *Ichnology* (1858, pp. 49-50) enumerates no fewer than thirty-eight quarries for fossil footprints and very few localities have been discovered since that time.

The more important localities, with the species each has produced, are as follows:

Massachusetts

Turners Falls area.—The northernmost locality is on the north bank of the Connecticut river, nearly opposite the mouth of Millers river. Species unrecorded.

Horse Race, Gill.—A very productive locality, from which are recorded the following species, alphabetically arranged:

Anchisauripus exsertus, *hitchcocki*, *minusculus*, *parallelus*, *sil-*
limani, *tuberosus*
Anomæpus scambus
Argoides minimus
Batrachopus deweyi, *dispar*, *gracilior*, *gracilis*
Corvipes lacertoideus
Eubrontes approximatus, *divaricatus*, *giganteus*
Grallator cuneatus, *cursorius*, *formosus*
Otozoum moodii
Palamopus palmatus, *rogersi*
Sillimanipus tetradactylus
Steropoides divaricatus, *diversus*, *ingens*

11 genera and 26 species.

Rock, gray micaceous sandstone and shale.

Lily Pond, Gill.—One of the most notable localities is that at the Lily Pond on the north bank of the Connecticut river ("Barton Cove" of the U. S. Geological Survey map), a locality that has produced not only a large proportion of vertebrate tracks but plant remains and nearly all of the known species of invertebrate trails as well. The rock is as a rule fine red and brown shale. The vertebrate species recorded are:

Ammopus marshi
Anchisauripus exsertus, hitchcocki, minusculus, parallelus, sillimani, tuberosus
Anomæpus curvatus
Anticheiropus hamatus
Apatichnus circumagens, minor
Arachnichnus dehiscens
Argoides minimus
Batrachopus bellus, deweyi, gracilior, gracilis
Chelonoides incedens
Comptichnus obesus
Corvipes lacertoideus
Eubrontes approximatus, divaricatus, giganteus, tuberatus
Exocampe ornata
Gigandipus caudatus
Grallator cuneatus, cursorius, formosus
Harpedactylus gracilior, tenuissimus
Hyphepus fieldi
Lagunculapes latus
Otouphepus magnificus
Otozoum minus
Palamopus gracilipes, palmatus, rogersi
Platypterna concamerata, digitigrada, gracillima, delicatula
Plectropterna angusta, gracilis, lineans
Plesiornis pilulatus
Sauropus barrattii
Selenichnus breviusculus
Shepardia palmipes
Sillimanius tetradactylus
Stenonyx lateralis
Steropoides diversus, elegans, ingens, infelix, uncus
Tarsodactylus caudatus

In all 31 genera and 57 species.

Ferry above Turners Falls.—Another important locality is the "Ferry above Turners Falls," near where the bridge now crosses from Turners Falls village to Riverside.

The character of the sediment is red shale.

The species from this locality recorded are:

Ammopus marshi
Anchisauripus exsertus, sillimani
Anomæpus curvatus, gracillimus, intermedius, scambus
Apatichnus minor

Argoides minimus
Batrachopus deweyi, gracilis
Exocampe ornata
Grallator cuneatus, cursorius, gracilis
Otouphepus magnificus
Orthodactylus sp.
Palamopus rogersi
Platypterna delicatula, digitigrada, tenuis
Plectropterna gracilis
Plesiornis pilulatus
Selenichnus breviusculus
Stenonyx lateralis
Steropoides diversus, infelix

In all 17 genera and 27 species.

Ferry at Turners Falls.—Character of sediment, gray micaceous sandstone.

Known species referred specifically to this spot are:

Ammopus marshi
Anchisauripus exsertus, minusculus, parallelus, sillimani
Anomæpus curvatus, gracillimus, intermedius, minimus, scam-
bus
Apatichnus circumagens
Batrachopus gracilis
Grallator gracilis
Hoplichnus poledrus
Otozoum minus
Selenichnus breviusculus

Number of genera 9; of species 16.

North bank below Turners Falls.—Character of sediment, gray shale.

Species recorded:

Ancyropus heteroclitus
Eubrontes giganteus
Exocampe arcta, ornata
Harpedactylus gracilior, tenuissimus
Helcura anguinea
Palamopus rogersi
Plectropterna gracilis, minitans
Sillimanius gracilior
Toxichnus inæqualis
Xiphopeza triplex

Number of genera represented 10; of species 13.

Turners Falls.—A great many specimens bear the general label of Turners Falls, which may belong either to the ferry at Turners Falls or to one of the other localities already specified. However, the building of the Turners Falls power dam at the cataract laid bare the river

bed, and this, together with the attendant quarrying operations, proved a golden opportunity for the gathering of these interesting relics. The character of the sediment ranges from micaceous sandstone through gray to red and finally indurated shale.

The genera and species from this locality are:

Amblypus dextratus, sp. indet.
Anchisauripus exsertus, *hitchcocki*, *minusculus*, *parallelus*, *sillimani*, *tuberosus*
Ancyropus heteroclitus
Anomæpus crassus, *curvatus*, *gracillimus*, *intermedius*, *isodactylus*, *minimus*, *scambus*
Antipus bifidus, *flexiloquus*
Apatichnus circumagens, *minor*
Arachnichnus dehiscens
Argoides macrodactylus, *minimus*
Batrachopus bellus, *deweyi*, *gracilior*, *gracilis*
Cheirotheroides pilulatus
Comptichnus obesus
Corripes lacertoideus
Eubrontes approximatus, *divaricatus*, *giganteus*, *tubervatus*
Exocampe arcta, *minima*, *ornata*
Gigandipus caudatus
Grallator cuneatus, *cursorius*, *formosus*, *gracilis*, *tenuis*
Harpedactylus crassus, *tenuissimus*
Helcura surgens
Hyphepus fieldi
Isocampe strata
Lagunculapes latus
Orthodactylus introvergens, *linearis*
Otozoum minus
Palamopus gracilipes, *palmatius*, *rogersi*
Platypterna concamerata, *deanai*, ? *delicatula*, *digitigrada*, *recta*
Plectropterna angusta, *elegans*, *gracilis*, *lineans*, *minitans*
Plesiornis pilulatus
Sauropus barrattii
Selenichnus brevisculus, *falcatus*
Shepardia palmipes
Sillimanius gracilior, *tetradactylus*
Stenonyx lateralis
Steropoides divaricatus, *diversus*, *infelix*, *uncus*
Sustenodactylus curvatus
Tarsodactylus caudatus
Toxichnus inæqualis
Triænopus baileyi
Trihamus elegans
Xiphopeza triplex

This profuse fauna contains no fewer than 39 genera and 82 species.

Field's Orchard, Gill.—An important quarry at this locality has produced red shale and sandstone bearing imprints of the feet of

Amblypus dextratus
Anchisauripus exsertus, parallelus, sillimani, tuberosus
Anomæpus curvatus, gracillimus, intermedius, minimus, scam-
bus
Apatichnus circumagens
Arachnichnus dehiscens
Argoides minimus
Batrachopus gracilis
Corvipes lacertoides
Eubrontes platypus, tuberatus
Exocampe minima
Grallator cuneatus, cursorius, formosus, ? gracilis
Hyphepus fieldi
Orthodactylus ? introvergens
? Palamopus rogersi
Platypterna concamerata, digitigrada
Plectropterna minitans
Sauropus barrattii
Xiphopeza triplex

In all 18 genera and 30 species.

Montague.—Dexter Marsh's quarry, in southwestern part of Montague. Rock, reddish micaceous sandstone.

Anticheiropus pilulatus
Argoides minimus
? Sauropus barrattii
Steropoides divaricatus, diversus
Trihamus elegans

Five genera and 6 species.

Montague Canal.—

Anchisauripus tuberosus
Eubrontes giganteus
Lagunculapes latus
Otozoum moodii

Four genera and 4 species.

Near Greenfield, Mass.—

Tarsodactylus expansus

Holyoke—Mt. Tom Range.—Outside of a few minor localities none is met with for a distance of about twenty miles, when one comes to the Holyoke-Mt. Tom range around which cluster a new group of footprint quarries. Here on the west side of Mt. Holyoke a few rods north of "Titan's piazza" in Hadley, an interesting locality is found, as it lies beneath the main trap sheet, not above as all to the north have done. This little quarry, like Bassett's quarry to the southwest of Mt. Tom in Easthampton, is of importance not from the profusion of

species which it has produced, but from this fact of its lying beneath the main trap sheet and therefore, except for those in the Chinle formation of the Southwest, presenting one of the earliest records of dinosaurian existence on our continent.

The forms preserved are all carnivorous dinosaurs; from Mt. Holyoke, *Anchisauripus tuberosus* and probably *exsertus*, and from Mt. Tom, upon coarse sandstone, *Eubrontes giganteus*, one of the most majestic of Newark forms.

On the eastern slope of the Mt. Tom uplift, therefore on the west bank of the Connecticut, are at least three localities, one of which lies "between the ridges of trap near Ashael Lyman's, in Northampton" (Hitchcock 1858), at a level above those just mentioned but still below the level of the uppermost trap. This quarry has produced two genera and four species impressed upon gray sandstone: *Anchisauripus exsertus*, *tuberosus*, the first being one of the largest representatives of the genus, *Eubrontes tuberatus*, and *Eupalamopus dananus*, a quadrupedal form of doubtful affinities.

At Smiths Ferry at the higher geological level, have been found the following impressed upon flagstone, often ripple-marked:

Anchisauripus exsertus, *minusculus*, *sillimani*, *tuberosus*
Eubrontes approximatus, *divaricatus*, *giganteus*
Grallator cuneatus, *formosus*
Platypterna concamerata
Steropoides divaricatus

Five genera and 11 species.

A small locality on the opposite side of the river has produced *Anchisauripus tuberosus*, one of the most common species, upon coarse sandstone bearing impressions of rain drops; while from South Hadley we have recorded:

Anchisauripus minusculus, *parallelus*, *sillimani*, *tuberosus*
Anomæpus curvatus, *isodactylus*, *minimus*
Apatichnus circumagens, *minus*
Batrachopus bellus
Eubrontes approximatus, *divaricatus*
Grallator cuneatus, *tenuis*
Steropoides divaricatus

In all 7 genera and 15 species.

Among the more specific localities within the town of South Hadley is Moody's corner, named for Pliny Moody, who first noticed the fossil footprints in so remote a year as 1802. This quarry is notable for having produced the type specimen of that most mysterious form, *Otozoum moodii*, in association with which were found:

Anchisauripus exsertus, *minusculus*, *parallelus*, *sillimani*, *tuberosus*
? Ancyropus heteroclitus
Anomæpus scambus

Apatichnus ? minor
Batrachopus deweyi
Grallator cursorius, formosus

Seven genera and 12 species.

The rock upon which the animals walked, a layer of red mud $\frac{1}{4}$ inch thick, could not be preserved, but the relief counterpart is composed of coarse reddish sandstone.

In the stream near Pliny Moody's upon coarse gray sandstone were found 3 genera and 4 species including the ubiquitous *Anchisauripus sillimani*, *Batrachopus ? deweyi*, and *Grallator formosus* and *tenuis*.

Dickinson's quarry, South Hadley, has specifically recorded:

Anchisauripus minusculus, sillimani, tuberosus
Anomæpus cuneatus, gracillimus, intermedius
Batrachopus deweyi
Eubrontes divaricatus
Grallator cuneatus, cursorius, tenuis

At least 5 genera and 11 species. It is highly possible that some of the other species referred to South Hadley may have come from this quarry.

Ashley Pond.—A quarry worked for commercial building stone situated to the west of the river in the town of Holyoke near Ashley Pond is said to have produced many footprints, quantities of which have been built into the foundations of the various mills in the city of Holyoke. One slab was shown me bearing two impressions which I identified as *Eubrontes giganteus* or *approximatus*. Of the other species no record is extant to my knowledge, as the locality has never been exploited scientifically, and as a rule when the commercially less valuable footprint layer is reached it is removed as speedily as possible.

Chicopee Falls.—At this locality, impressed upon hard black shale, were found:

Anchisauripus exsertus, sillimani
Anomæpus ? gracillimus
Argoides redfieldii
Grallator cuneatus, formosus
Plectropterna minitans
Plesiornis ? pilulatus
Polemarchus polemarchius

Seven genera and 9 species.

Chicopee.—Near the principal village of the town (formerly called Cabotville), some at least upon "slightly calcareous shale," were found:

Argoides macrodactylus
Plectropterna minitans
Polemarchus polemarchius
Sillimanius tetradactylus

In all 4 genera and species.

Connecticut

Crossing the border into Connecticut we come to still a third group of localities, all belonging to the higher geological level and all in proximity to the Connecticut river. The association of so many of the known localities with the present course of the river is probably due not so much to the absence of footprints elsewhere in the broad reaches of the valley as to the fact that in very few places away from the river is the Triassic sandstone exposed, it being for the most part covered with deposits of later geological age mainly of glacial origin.

Footprints have been found near Enfield bridge on the west bank of the river in Suffield, and at "Rocky Hill" in Hartford, but of the species I have found no record.

Wethersfield.—The northernmost important locality is at the cove at Wethersfield which also lies on the west bank of the river. Here the character of the rock ranges from red to brown shale, and the mud was as a rule so extremely soft when trodden upon by the Triassic denizens that the walls of many of the footprints have partially caved in, making a group of "leptodactylous" tracks which in my opinion are due rather to the state of plasticity of the surface than to morphological characters of the feet which thus impressed themselves. For as a rule there is always a ratio between the plantar area of a creature's feet and his weight, varying in different species with the character of the ground upon which he habitually walks. These "leptodactylous" tracks being found practically nowhere else, it is inconceivable that they can be a special adaptation to a muddy surface which places the animal at so marked a disadvantage as that of sinking in at every step.

The Wethersfield Cove fauna includes the following, in addition to which there may be some wrongly included under "Wethersfield" without specific reference to the cove:

Ancyropus heteroclitus
Argoides macrodactylus, minimus
Eubrontes giganteus
Exocampe ornata
Grallator cuneatus
Platypterna deanii, delicatula, tenuis
Plectropterna minitans
Sillimanius gracilior, tetradactylus
Trienopus baileyi
Typopus gracilis

In all 10 genera and 14 species.

At Wethersfield, about two miles south of the cove, is another locality, and a third lies about as far beyond the second. At one or both of these places there have been impressed upon soft mud, which has since solidified into a red shale, the following species:

Anchisauripus exsertus, minusculus, sillimani, tuberosus
Ancyropus heteroclitus

Anomæpus cuneatus, gracillimus
Argoides macrodactylus, minimus
Comptichnus sp.
Corvipes lacertoides
Eubrontes divaricatus, giganteus
Grallator cuneatus, cursorius, formosus, tenuis
Harpedactylus tenuissimus
Palamopus rogersi
Platypterna concamerata, deanii, delicatula, tenuis
Plectropterna elegans, gracilis, lineans, minitans
Plesiornis æqualipes (= ? *Argoides minimus*), *quadrupes* (= ?
Anomæpus intermedius)
Sillimanius gracilior, tetradactylus
Steropoides diversus, infelix
Triænopus baileyi
Trihamus elegans, magnus
Typopus ? abnormis

In all 18 genera and 37 species are represented.

Portland.—One of the most notable localities for the interest attached to the species is at Portland and on the east bank of the river. Here extensive abandoned quarries produced an excellent building stone. Occasionally a level bearing footprints was found, though nearly all the museum specimens preserved so abundantly at Wesleyan University as well as at the Hartford High School and at Yale are the counterparts, natural casts of the footprints themselves, preserved in high relief in coarse red sandstone.

Perhaps the most striking member of the Portland fauna is the immense *Otozoum moodii*, accompanied in great profusion by the tracks of *Anchisauripus sillimani*, as is also the case at Moody's corner, South Hadley. The complete faunal list is as follows:

Anchisauripus exsertus, sillimani, tuberosus
Batrachopus deweyi, gracilis
Cunichnoides marsupialoides
Eubrontes giganteus
Gigandipus caudatus
Grallator cuneatus, gracilis, tenuis
Hoplichnus equus (questionably of organic origin)
Isocampe strata
Otozoum moodii (= also *caudatum*)

There are thus recorded 8 genera and 13 species and 1 doubtful genus and species in addition.

Middletown and Middlefield.—From the neighborhood of Middletown,¹ comes the type specimen of *Anchisauripus sillimani* in high relief upon a slab of reddish micaceous sandstone which had been worn smooth on its upper surface as a flagstone in the streets of Middletown

¹As the town of Middlefield was not separated from Middletown until 1886, some of the specimens reported from Middletown may have come from Middlefield.

by the feet of two generations of men. It was dug from a quarry about two miles west of the city one hundred and thirty-odd years ago, but the quarry has since produced so far as I can learn no other relics of a similar character. There are two counterpart slabs in the Redfield collection at Yale (Cat. No. 2126) labeled as coming from Middletown and bearing footprints which I have identified as those of *Grallator cursorius*. The precise locality, however, is in doubt. *Sauropus barrattii* is also reported to have been found at Middletown; this may, however, refer to the Middlefield slab mentioned below.

A locality at Middlefield lying to the west of the easternmost trap ridge and therefore in the upper shales, older than the long series of quarries along the river yet younger than those beneath the main trap sheet at Mt. Tom and Mt. Holyoke, has produced among other footprints the earliest record of the tracks of a plant-feeding dinosaur known to me. The list includes:

Anchisauripus exsertus, minusculus, sillimani
Anomarpus gracillimus
Eubrontes giganteus, tuberatus
Grallator cursorius

Four genera and 7 species. There have also been reported from Middlefield upon a sidewalk flagstone of doubtful origin:

Batrachopus gracilis
Sauropus barrattii

At Higby, footprints have been reported in the lower shales by Davis (1898, p. 138), by whom Mr. S. Ward Loper was engaged to search for fossil fish localities "at the proper horizons for a considerable distance along the anterior and posterior valleys in the larger blocks, from Totoket Mountain northward to the gorge of the Farmington river at Tariffville. . . . The drift cover proved a serious obstacle to success, but did not entirely defeat the search. After repeated failure to find outcrops in the long anterior valley from Tremont to the north end of Higby Mountain, the shales holding a few fish scales were discovered in a little ravine near the north-bounding fault, and on making an opening here, some of the characteristic fossils of the anterior shales were speedily found. Associated with them was a bed of sandstone containing *plentiful large reptilian footprints*" (italics mine).

No statement is made by Davis concerning the species of footprints, and I have been unable thus far to locate the material if it was collected. The species ought however to accord with those from Mt. Tom and Mt. Holyoke, that is, *Anchisauripus tuberosus*, possibly *A. exsertus* and *Eubrontes giganteus*, and I offer this as a prediction of their identity when they shall have been studied.

New Haven.—Footprints were also reported from near the quarry and presumably from the same geological level as that which produced the specimen of *Stegomus arcuatus* at New Haven. They were, however, neither preserved nor recorded: which seems little short of cal-

amitous in view of the fact that not only were they at the farthest possible southern limit of the valley, but, lying as they did, within the limits of the lower series of coarse granitic sandstones (see geologic section on p. 16), they were far anterior in time to any of the footprints actually preserved in the Connecticut valley.

North Branford. Sugar Loaf Tunnel.—This tunnel which extends for 13,504 feet, is part of the New Haven water supply system and cuts through a mass of rock belonging to the upper (posterior) shales and sandstones of the Meriden group. Fossils were found at several localities in the tunnel one of which was in the black-shale horizon with fish and plant remains; the others were composed of shales, massive tough gray sandstone, and arkose, with numerous footprints, many of which were in high relief on the underside of the tunnel roof.

The following species have been determined by Thorpe (1929) and are in the Yale Peabody Museum:

Anchisauripus exsertus, *exsertus* subsp. *branfordi*, *hitchcocki*,
parallelus, *sillimani*, *tuberosus*
Batrachopus deweyi
Eubrontes approximatus, *giganteus*
Gigandipus caudatus
Shepardia palmipes
Trienopus lulli

Number of genera 7; of species 13; subspecies 1.

Stratigraphical Distribution

The geologic sequence of the valley footprint localities is:

New Haven arkose, lower series, coarse granitic sandstone
 New Haven, *Stegomus* quarry

Meriden series, lower shales
 Higby, Conn.

Bassett's quarry, southwest of Mt. Tom; Mt. Holyoke, Mass.
 Meriden series, upper shales

Middlefield, Conn.

Between the ridges of trap near Ashael Lyman's in Northampton, Mass.

East face of Mt. Tom, Mass.
 North Branford, Conn.

Portland series, sandstones and shales

Portland-Wethersfield group, Conn.

South Hadley group, Mass.

Turners Falls group, Mass.

Of these the Portland locality and that at Moody's corner containing the great *Otozoum* may be a little the newest (Emerson).

TECHNICAL DESCRIPTIONS

THE SKELETAL REMAINS

The Triassic skeletons of the Connecticut valley and adjacent region are all reptilian, representing but two orders and but a meagre proportion of the entire fauna. A résumé of the known forms is as follows:

Class **REPTILIA**Order **THECODONTIA**Suborder **Pseudosuchia**Family **STEGANOLEPIDÆ*****Stegomus arcuatus* Marsh**

Marsh, O. C. 1896, Amer. Jour. Sci., (4) ii, pp. 59-62, pl. i.
Holotype; Cat. No. 1647, Y. P. M.¹

✓ *Locality*.—Quarry of Freeman Clark near the Tomlinson bridge over the Quinnipiac river in Fair Haven, within the municipality of New Haven, Connecticut.

✓ *Horizon*.—West of the lower (anterior) trap sheet within the limits of the lower series of coarse granitic sandstone (New Haven arkose).

Original Description.—"The fossil shows the impression of the dermal armor of a large reptile, which apparently represents a new genus of the *Belodontia*. The dermal covering thus preserved is mainly from the dorsal region, although the anterior part protected the back of the neck. No other portions of the dermal armor nor any of the skeleton were found, although a careful search was made at the time of the discovery and subsequently, both at the locality itself and in the vicinity. It is therefore probable that the dermal covering here described was torn from the animal after death and before entombment in the coarse sand and gravel then deposited by a strong current, as indicated by the present structure of the sandstone.

"In the fossil represented in the accompanying plate [Plate V], the dorsal region of the reptile is shown, with the anterior portion to the left. The median dorsal line is indicated by the narrow longitudinal ridge, placed nearly horizontal in the figure. In the cervical region, this nearly straight line is broken, as the armor was here turned slightly to the right and somewhat twisted. This median ridge was formed by the matrix filling the narrow space between the ends of the transverse ridges, where they met in pairs on the median line. The transverse ridges are likewise due to the filling in of the matrix between the adjoining plates, which evidently were somewhat separated by connecting tissue admitting of more or less motion, but which held the whole dorsal armor together as a carapace.

"The large median plates indicated in this fossil are twenty in number in each of the two rows meeting on the middle line. These

¹Yale Peabody Museum.

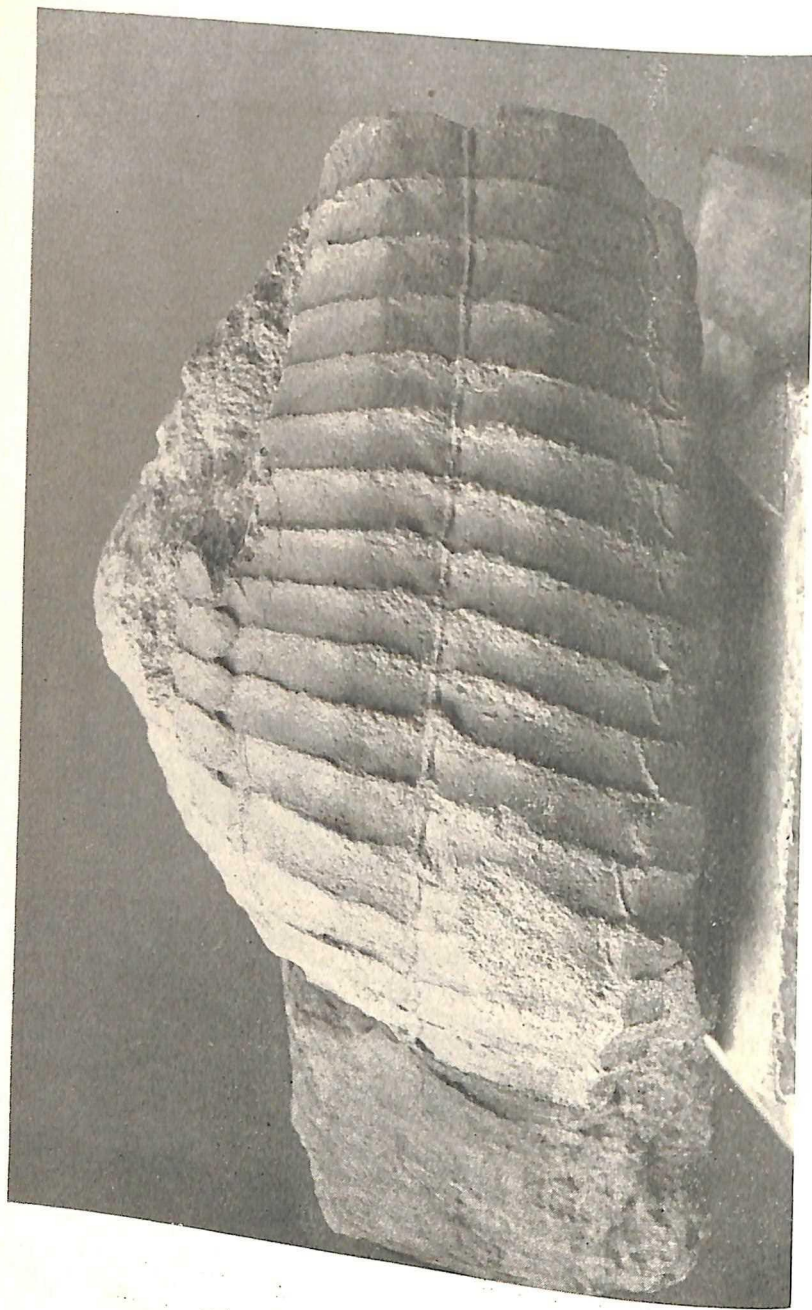


PLATE V.—Impression of the dorsal armor, under side, of the pseudosuchian *Stegonius arcuatus* Marsh. Cat. No. 1647, Y. P. M. One-third natural size, after Marsh. Courtesy of the Yale Peabody Museum.

plates are elongated transversely, strongly convex, and their form is accurately shown in the figure. Their inner extremities are nearly at right angles to the sides, but the outer ends are oblique where they join the plates of the lateral series, or second row. These lateral plates were quite short, and their form and position are clearly preserved in the specimen figured. All the dermal armor indicated resembles, in its general features, the corresponding portions in the genus *Aëtosaurus* Fraas, from the upper Trias of Germany. In the latter, however, the plates are imbricate [*vide infra*].

"The above description is based upon the impressions left by the inferior side of the plates upon the plastic matrix in which they were imbedded. The plates themselves have since disappeared, having been dissolved by infiltrating waters. The cast of the superior surface of the plates was of somewhat softer material than the matrix below, and most of it was lost in removing the specimen. The portions recovered show that the upper surface of the plates was rugose, but not deeply sculptured, being less marked in this respect than in the other known species of *Belodonts*. The rough surface preserved shows no regular pattern of ornamentation, and there are no indications of a crest on the plates. The form and position of the plates are characteristic features, and as both the genus and species appear to be distinct, the reptile may be known as *Stegomus arcuatus*. The animal when alive was of moderate size, probably eight or ten feet long. This would be about two-thirds the size of *Belodon validus* [*vide infra* p. 91]. The scapula of which is eight and one-half inches in length. The fossil here described indicates an animal with a body capable of some lateral flexure and considerable vertical movement. The type specimen was found by F. P. Clark, and presented by D. A. Van Hise to the Yale University Museum."

Additional Description.—The rock is a coarse-grained arkose sandstone, reddish brown in color, and showing no bedding planes. This rock, though coarse, is nevertheless a high-grade building stone. It seems, therefore, to have come within the hardening influence of the trap, though showing no trace of thermal metamorphism.

There is no bone remaining, though bone seems to have been present until after the hardening of the sediments, as the spaces occupied by the dermal bones of the carapace would still be present were the portion of matrix which overlay the specimen yet in place. Enough of the upper rock still remains to indicate this when the detached fragments are returned to their proper place.

I cannot agree with Marsh that the plates show no indication of imbrication, as this is clearly shown by the overlying matrix giving as it does the character of the external surface of the carapace. The anterior margin of some of the plates was depressed as much as 5 mm. below the posterior margin of the one in front. The average depression is about 4 mm. Emerson and Loomis (1904, p. 378) state that in *Stegomosuchus longipes* "the rear margin of each scute overlapped the front of the succeeding one, as is clear in the cast of the upper surface. Marsh considered that in his specimen this was not the case, but the

fossil shows only the under surface of the scutes and they appear exactly as do those in the specimen under description. Marsh used this character to distinguish *Stegomus* from *Aëtosaurus*, but the contrasts must be found in other characters, as is shown later." These authors overlooked the fact that fragments bearing the impression of the dorsal surface of the carapace of *Stegomus arcuatus* were preserved, though Marsh specifically mentions them. The latter, however, overlooked the perfectly obvious imbrication which the overlying matrix indicates and which is relatively the same as that of the lesser specimen described by Emerson and Loomis.

As in the case of the latter specimen, the upper matrix is coarser in texture than the lower, so that while the character of the lower surface of the scutes is faithfully preserved that of the upper surface is apparently obscured by the coarse granulation of the material taking the impression. This difficulty, however, is more apparent than real. For a plaster cast in which varying color and size of the sand grains is eliminated gives a true idea of the surface of the bone itself, which is covered by tiny punctuations in series approximately parallel to the anterior and posterior margins of the plate, that is, perpendicular to the long axis of the animal's body. A square centimeter covers about seventy such punctuations arranged in eight rows, which gives an idea of their minuteness upon so large an animal. In *Aëtosaurus* the scutes bear radially arranged ridges upon their upper surface, the center of radiation being eccentrically placed. This would in itself constitute the greatest point of distinction between *Stegomus* and *Aëtosaurus* were the New Haven specimen of the former genus alone known.

Available dimensions of *Stegomus arcuatus* are as follows:
Length of entire carapace as preserved

Measured over curve	440 mm.
Measured between perpendiculars	410 mm.
Average greatest fore and aft dimensions of plates (median row)	25 mm.
Average least diameter	20 mm.
Transverse diameter of largest (10th) plate	94 mm.
Transverse diameter of least (4th and 18th) plates	75 mm.
Average transverse diameter of lateral plates	40 mm.

Stegomus arcuatus jerseyensis Jepsen

Jepsen 1948, pp. 5-17, pl. 1.

Holotype.—New Jersey State Museum, No. 10740.

Material.—Nine segments of the tail cuirass and four caudal vertebrae. From shale of the Brunswick formation near Neshanic, New Jersey. An exact comparison with the type of *Stegomus arcuatus* cannot be made for they pertain to different parts of the body, the New Haven specimen consisting of the matrix impression of the *under* side of the dorsal armor plates with no trace of bone whatever, and the New Jersey specimen of the actual caudal armor plates with four enclosed vertebrae. Nevertheless, Jepsen places the two specimens in the same genus and species, but remarks that the New Jersey specimen

"is in fact here regarded as part of an individual of *Stegomus arcuatus*, although for taxonomic convenience and because the two specimens probably were genetically separated (not members of a single interbreeding population), it is treated as representing a new sub-species, *S. jerseyensis*.

Stegomosuchus (Stegomus) longipes (Emerson and Loomis)

Emerson, B. K., and Loomis, F. B. 1904, Amer. Jour. Sci., (4) xvii, pp. 377-380, pl. xxii.

Lull, R. S. 1904, Pop. Sci. Monthly, p. 148, text fig. p. 147.

V. Huene, 1914, pp. 17-19, fig. 42.

Holotype.—Deposited in the museum of Amherst College.

✓ *Locality*.—Hine's quarry, about a mile east of the village of Longmeadow, Massachusetts.

✓ *Horizon*.—Longmeadow sandstone, in the "upper [Portland] series of sandstones and shales with local conglomerates" of the Connecticut valley.

Original Description.—"The specimen consists of three pieces containing the major part of the whole animal. All but a thin interrupted film of bone has been leached out, leaving spaces which are filled with calcite. It is, then, largely a cast, both the upper and lower surfaces of the bone impressed on one block or the other. The first block contains most of the fossil, the splitting having exposed the under surface of the bones roofing the head, of the carapace from the head to the pelvis (28 pairs of plates), the bones of the right arm and left foot. The second block contains the impression of the upper surface of the same parts. The third is a chip, flaked off just in front of the pelvis and exposing the vertebræ of that region.

"*Skull*.—This is broadly triangular in outline, tapering to a pointed snout. The upper surface of the cranium seems to have been completely roofed with bone, except possibly directly over the orbit. Two supraorbital bones are distinctly indicated, but between them and the frontals is a space which seems to have been open (see ? in fig. 2, Pl. xxii) [fig. 9 B]. Sutures are present showing that the dermal bones were paired along the middle line. The premaxillæ are short, the nasals are rather long, but the boundaries of the other bones cannot be made out. A vertical break shows the side of the skull imperfectly, as restored in fig. 3, Pl. xxii [fig. 9 A]. The parts actually present are indicated by the complete line, while restoration is indicated by a broken line. It is a low skull, being about one-third as deep as long. The quadratum is well back, making a long jugal arch. An antorbital vacuity is present though its boundaries are very imperfectly indicated. The orbit is moderately large, being distinctly bounded off from the temporal vacuities as indicated. It has above it at least two supraorbital bones. That there is a large lateral temporal vacuity is certain. A forward projection of bone in the squamosal region seems to indicate a dividing arcade between this and a supra-temporal vacuity, but the arcade is not complete and is not therefore certain. Or the maxilla of the left side one tooth and a part of a



PLATE VI.—The pseudosuchian *Stegomosuchus longipes* (Emerson and Loomis) A, Dorsal aspect, B, Visceral aspect of the armor. About natural size. Courtesy of Amherst College. Photographs by P. A. Morris.

second is preserved, showing them to be tiny conical affairs. The depth of the lower jaw is about 3 mm., being a light slender mandible.

"Carapace."—The dorsal side of the body was protected by a double row of plates, on either side. Those along the middle line are wide, their outer edges being flanked with small quadrate scutes. From the head to the pelvis there are 28 sets of plates, which are narrow and inflexed in the neck region, widen till the middle of the body is reached, and then gradually taper toward the tail. The arrangement and relations of these scutes are seen in fig. 2 [fig. 9 B]. Each plate of the median row is usually about $4\frac{1}{2}$ mm., from front to back. The third and fourth, however, are about half as wide as the rest, while the fifth is much the widest, being wider than the two preceding taken together. Possibly some of this variation is due to the curvature of the neck, but most of it is clearly the bone itself. The rear margin of each scute overlapped the front of the succeeding one, as is clear in the cast of the upper surface. . . . Along the outer margins of plates 5-9 small quadrate scutes were brought into sight by preparation. The nature of the fossil does not permit further preparation, but doubtless similar scutes occur all along the side of the body. On the cast of the upper surface of the scutes, there are indications that the surface was pitted, but the coarseness of the sandstone prevents certainty.

"Vertebrae."—Three presacrals are exposed, each deeply biconcave and with long transverse processes. Two vertebrae only are involved in the sacrum, their moderately long transverse processes supporting the ilium. How completely they are united is not clear on account of the broken condition of the vertebrae, but they appear slightly separated. Three and a half deeply biconcave caudals are all that are preserved. The transverse processes of these are even longer than on the presacrals and quadrate in section. From the sacrum back they are progressively longer, suggesting a broad flat tail such as is known for *Aëtosaurus*.

"Fore Limb."—Of the pectoral girdle only the scapula is present, and this is a broad triangular bone 9 mm. long by 5 mm. deep. Its upper margin lies parallel to small lateral plates 7-9 in the series. The leg is unusually long, the slender humerus being $1\frac{1}{2}$ mm. in diameter and 24 mm. in length, a bone nearly straight and swelling slightly at either end. The radius and ulna are but $\frac{3}{4}$ mm. in diameter and 19 mm. long. As the specimen lies, the radius crosses the ulna, but whether this indicates great flexibility or is mere chance is not to be determined. The fore foot is lacking.

"Hind Limb."—An ilium 12 mm. long, the front and rear ends of which curve strongly outward, is present, but only its rough outline is to be made out. Of the limb bones only short fragments are discernible, where they are broken across; but enough is visible to show the direction and diameter of the bones, and by extending these the length can be approximately found. This indicates a leg slightly longer than the fore leg. The femur was $1\frac{1}{2}$ mm. in diameter and 26 mm. in length (by reconstruction). The tibia and fibula are each

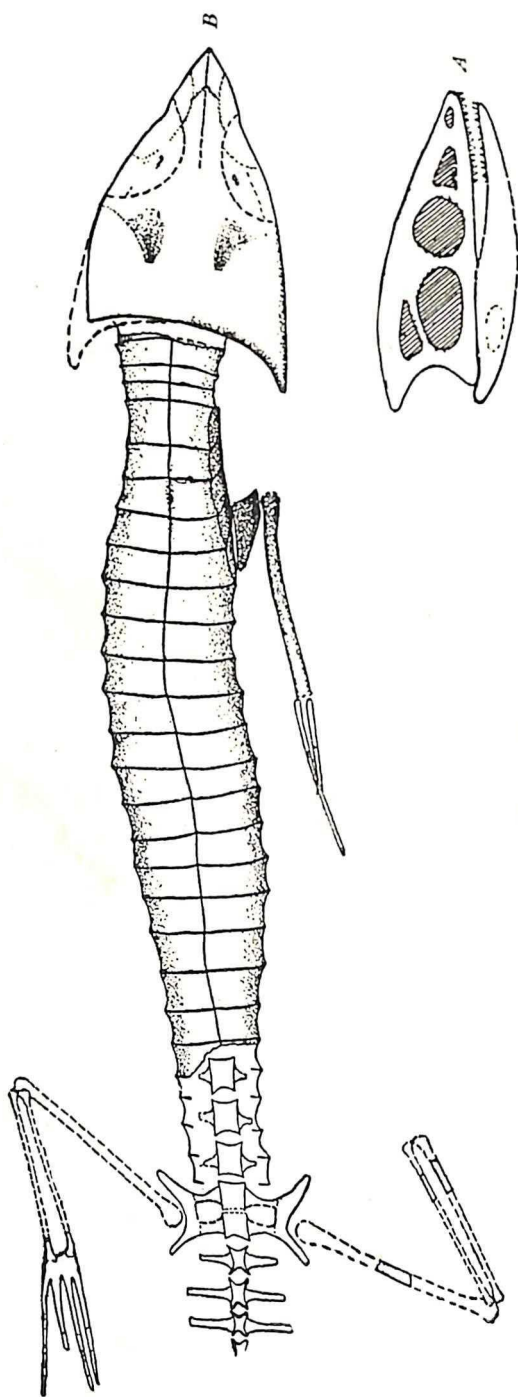


FIGURE 9.
Stegomosuchus longipes (Emerson and Loomis), Natural size. After Emerson and Loomis. A. Right side view of skull. B. Dorsal view of head and body.

about the same size, $\frac{3}{4}$ mm. in diameter and 21 mm. long (by reconstruction). The left foot is well preserved. The individual tarsals are not to be made out. Four toes are well preserved, but a fifth is nowhere even indicated. The length of the toes on the figure is probably a little short, as each seems incomplete at the end. The metapodials are long, but the details of the toes do not come out with certainty, though a slight widening at intervals was taken to indicate the joints, and they are drawn on that supposition.

"*Comparison.*—This animal resembles most closely Marsh's *Stegomus arcuatus*, of which twenty dorsal sets of plates are described. It is a much smaller species and presents most of the important features, thus allowing a conception of the animal and its relationships. [*Stegomus*] *Stegomus longipes* is about one-third [*vide infra*] the size of the preceding species, which is the only comparison readily made, as Marsh's fossil is so incomplete. [It resembles the genus *Aëtosaurus*] in many important features, but there are enough characters of weight to demand a separate genus, as established by Marsh. *Ornithosuchus* and *Erpetosaurus* of Newton¹ also have some features resembling *S. longipes* but are far wider differentiated than the German genus. *Aëtosaurus* has about twenty-five pair of large scutes and small to the pelvis, each consisting of a median pair of large scutes and small quadrate scutes outside these. *Stegomus* has about twenty-eight exactly similar [*vide infra*] sets of plates.

"In the skull, however, there are marked contrasts. The orbit of both genera is bounded above by extra supraorbital bones, but the orbit of the *Aëtosaurus* is further back than that of *Stegomus* [*Stegomus*]; the result of which is that the former has only a single small supra-temporal vacuity, while the latter has at least a very large small supra-temporal vacuity, and possibly that divided into a supra-temporal and a lateral temporal vacuity. The *Stegomus* [*Stegomus*] has a wider skull and above the orbit a vacuity or at least a deep depression. The vertebræ of *Aëtosaurus* are procœlous, while those of *Stegomus* [*Stegomus*] are amphicœlous. *Ornithosuchus* has platycœlous vertebral centra. The sacrum in the other known *Aëtosauridæ* includes three vertebrae, but in *Stegomus* [*Stegomus*] only two are united to the ilium. Both the fore and hind limbs of *Stegomus* [*Stegomus*] are much longer and more slender than the *Aëtosaurus*, this being the character which has suggested the specific name *longipes*.

"The features above described show this fossil to be the remains of a small armoured lizard-like creature with long legs. It seems to be a land form and of extreme agility.

"The following are the measurements of the principal parts:

Length from snout to root of tail	149 mm.
Length of skull	35 mm.
Breadth of skull in occipital region	27 mm.
(29 allowing for fracture)	
Depth of skull in quadrate region	11 mm.

¹Newton, E. T., 1894, Phil. Trans., vol. clxxxv. Reptiles of Elgin Sandstones.

Median Plate 2	8 mm. transversely by $4\frac{1}{2}$ longitudinally
" Plate 3	$5\frac{1}{2}$ " " 2 "
" Plate 4	5 " " $2\frac{1}{2}$ "
" Plate 5	$4\frac{1}{2}$ " " 5 "

"The succeeding plates gradually increase transversely up to 10 mm. at about the middle of the body and then slowly diminish again. All are drawn to scale in figure 2, Pl. xxii [fig 9 B].

"The vertebral centra in front of the pelvis are $3\frac{1}{2}$ mm. long by 3 mm. wide. Caudal vertebræ 3 mm. long by 2 mm. wide. The transverse process of the last vertebræ are 6 mm. long."

Additional Description.—The original specimen has not been available for my study, but from a squeeze taken some years ago the figure of the skull (not shown) has been made. It differs in some details from that published by Emerson and Loomis, probably for the reason that their figure was drawn from the first block, showing the impression of the under side of the cranial bones, while mine was from the second block, which contains the impression of the upper surface, and hence the squeeze gave an actual reproduction of the dorsal aspect of the skull itself. The supra-temporal vacuities are plainly indicated, and I have carried out the apparent lines of the muzzle in such a way as to make it longer and more attenuated, more as in *Aëtosaurus*. The proportions of the skull with the position of the orbit are still however quite different from those of *Aëtosaurus* as the authors indicate.

The punctate character of the surface of the dermal bones of *Stegomosuchus* differs markedly from that of *Aëtosaurus*, where the scutes are ornamented by radially arranged striæ. Therefore the scutes are not "exactly similar" as Emerson and Loomis have said. Specific distinctions between *Stegomus arcuatus* and *Stegomosuchus longipes* are, first, that of size, the *Stegomus arcuatus* being about six times larger than *longipes*, not thrice as the authors state. Another distinctive feature is in the character of the outer margin of the median row of dermal plates in *Stegomus arcuatus*, which is oblique, forming a decided angle with the front and rear margins. On the other hand in *longipes* these outer margins are very nearly parallel to the median line of the animal with only a slight tendency to diverge at the rear edge of each plate. As I have shown, the supposition that in *arcuatus* the dorsal scutes are non-imbricate is erroneous; the two species being similar in this respect as well as in the finely punctate character of the outer surface of the bone.

Stegomus arcuatus comes from the lower series of sandstones (New Haven arkose) of the Connecticut valley, following which are the lower trap, lower shales, main trap sheet, upper shales, upper trap and a very considerable deposition of the upper (Portland) series of sandstones and shales, before the horizon of the Longmeadow sandstone containing *Stegomosuchus longipes* is reached, implying a great lapse of time, as more than 2,000, perhaps more than 3,000, feet separate the nearest limits of the sandstones which bear them.

Aëtosaurus seems to have been a terrestrial reptile. The marvelous group of twenty-four skeletons which were preserved in the museum at Stuttgart apparently implies that the animals were killed by the caving in of the sandy roof of the shelter in which they had taken refuge. One at least is pathetic in its appealing efforts to escape as indicated by its posture. *Stegomosuchus* again seems to have been terrestrial, at least *S. longipes* does; of *Stegomus arcuatus* one cannot be quite so sure, as the remains are too meagre to speak of their owner's adaptations and the body was embedded in stream-borne sediment. *S. longipes* on the other hand seems to show a distinct cursorial adaptation; and I have correlated the animal with the footprint species *Batrachopus gracilis* (Lull 1904 C, p. 381; *vide infra* p. 238), in which the quadrupedal gait, long stride, and narrow trackway imply a mammal-like mode of progression while the tracks of hand and foot are distinctly reptilian.

The size, proportions, long, slender limbs with straight-shafted bones unlike those of a modern sprawling reptile,—all are arguments in favor of the cursorial gait shown in the restoration, plate II, page 23 (see Lull 1904 B, p. 147, fig.). Emerson and Loomis refer to the crossing of the ulna by the radius but cannot determine whether this indicates great flexibility or is mere chance. It seems rather to be in line with the present argument, for the ulna, being articulated with the inner condyle of the humerus and the external side of the wrist, will naturally be crossed by the radius when the elbows are drawn in against the animal's side and the digits directed forward palm down—in other words, in the mammalian attitude of the limb which was also that assumed by the quadrupedal dinosaurs.

Suborder Phytosauria (Parasuchia)

Clepsysaurus validus (Marsh)

Marsh, O. C. 1893, Amer. Jour. Sci., (3) xlv, p. 170 (*Belodon*).

Marsh, O. C. 1896, Amer. Jour. Sci., (4) ii, p. 59.

McGregor, J. H. 1906, Mem. Amer. Mus. Nat. Hist., ix, pt. ii, p. 95 (*Rhytidodon carolinensis*).

Lull, R. S., 1915, pp. 109-113, fig. 12 (*Rutiodon validus*).

Holotype: Cat. No. 2138, Y. P. M.

Locality.—Simsbury, Conn., in the quarry of Orestes Wilcox, half a mile southwest from the station; found in 1888.

Horizon.—Below the lower (anterior) trap sheet; approximately the same level as that of *Stegomus arcuatus* (*vide supra* p. 79).

Original Description.—"The only other reptile known from the Connecticut sandstone by any part of the skeleton is a large *Belodon* from a lower horizon. This crocodilian may be called *Belodon validus*, and will be described by the writer later."

The only further reference to this species by Marsh is in the description of *Stegomus arcuatus* (Marsh 1896 A, p. 59) in which he says:

"The *Belodontia*, one of the most characteristic groups of Triassic reptiles, are almost unknown in the Connecticut river sandstone, a single specimen only having been discovered, and recently named by the writer *Belodon validus*." Again (*op. cit.* p. 60) Marsh says in speaking of the size of *S. arcuatus*, "The animal when alive was of moderate size, probably eight or ten feet long. This would be about two-thirds the size of *Belodon validus*, the scapula of which is eight and one-half inches in length." Marsh's promise of further description was thwarted by destiny.

McGregor (1906, p. 95) includes under the species *Rhytidodon* (*Rutiodon*) *carolinensis* no fewer than fifteen names which he believes

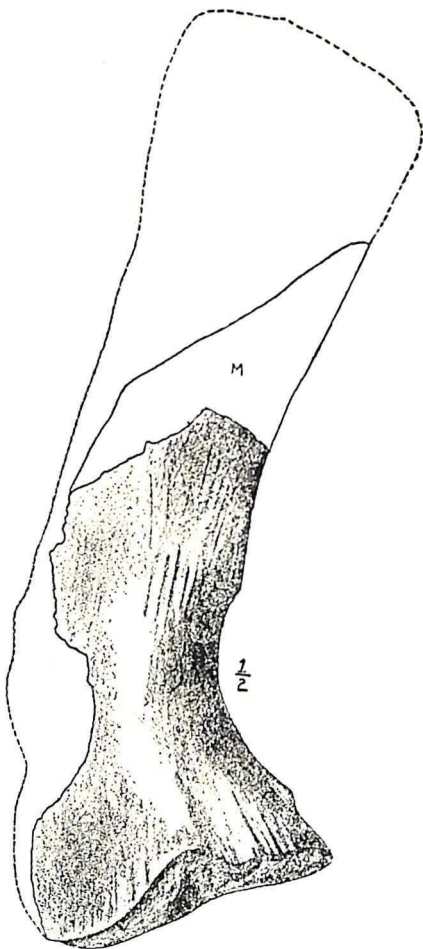


FIGURE 10.
Clepsysaurus validus (Marsh). Left scapula.
One-half natural size. After Lull.

"all synonyms, with the possible exception of *Belodon* [*Clepsysaurus*] *validus*, from the Trias of Connecticut, which was named, but not described, by Marsh."

Character of the Specimen.—The specimen consists of the proximal portion of the right scapula only, with the outer aspect still embedded in the rock so that some of the details are obscured. Compared with the figure of the left scapula of *Rutiodon carolinensis*, published by McGregor (*op cit.*, pl. IX, fig. 20), the bone under discussion seems to be about half again as large in most of its dimensions except the vertical length of the glenoid fossa. The description of the bone in *R. carolinensis*, p. 70, tallies with that of *validus* in so far as the details of the latter specimen are preserved, except that *validus* seems to be relatively more robust. The union with the coracoid is, as McGregor says, a synarthrosis, permitting little or no motion, and in the synarthrosis the scapular surface is concave. This concavity does not seem to tally exactly with that of *carolinensis* if one may judge from the figure of the complementary surface of the coracoid, for a ridge on the latter, indicating a corresponding groove on the proximal end of the scapula, runs obliquely forward and inward in *carolinensis* while in *validus* it is almost transverse though inclining slightly backward instead of forward. Above the glenoid face in *carolinensis* very distinct roughenings are indicated on the posterior aspect of the scapula, in *validus* the same area is smooth in so far as it is possible to observe it. There is also in the figure of *carolinensis* a very distinct fissure defining the forward limitation of the glenoid fossa, which is lacking in *validus*.

The principal features therefore in *Clepsysaurus validus*, in contrast to *carolinensis*, are its greater robustness, absence of the roughening above the glenoid fossa, absence of the posterior defining fissure, and the position of the transverse groove on the coracoid facet. On these distinctions the validity of *validus* must rest.

The principal measurements are:	215 mm.
Estimated length (Marsh's)	64 mm.
Antero-posterior diameter of coracoid facet	35 mm.
Transverse diameter of coracoid facet	56 mm.
Greatest diameter of proximal end	

McGregor (p. 92) thus characterizes the Phytosauria, to which group *Clepsysaurus validus* belongs:

"Large diapsid reptiles, strongly resembling the Crocodilia in external form and in habit, but differing in the fact that the elongate snout is prenasal (formed almost entirely by the premaxillary bones), the nares separate, and located near the eyes, internal nares directly below external; no secondary palate. Teeth of carnivorous type, conical or with trenchant edges. . . . Dermal armature on neck, trunk, and tail consists of sculptured bony plates, arranged metamerically on the dorsal surface, usually in four series. Ventral surface naked (?) or partly protected by a throat-shield of small scutes.

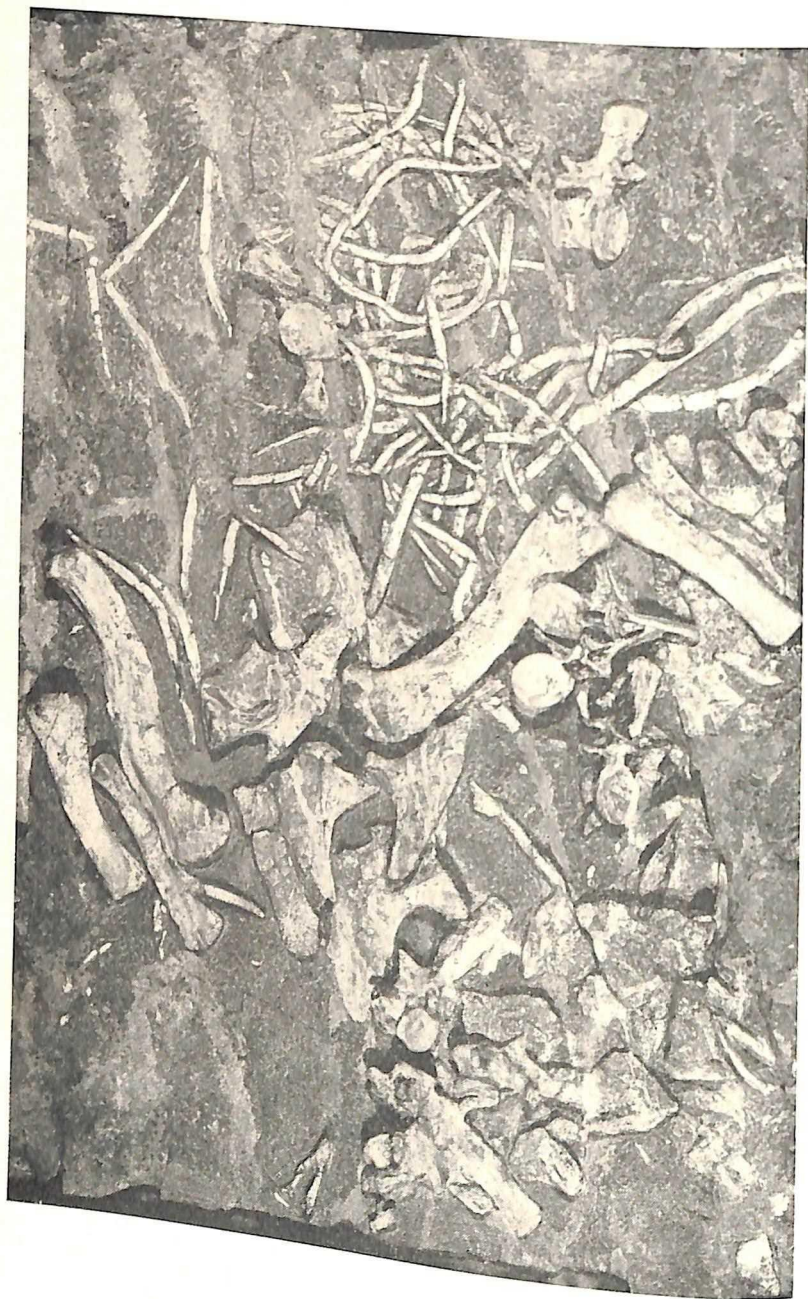


PLATE VII.—The phytosaurian *Clepsysaurus manhattanensis* von Huene.
The Fort Lee specimen as prepared. Cat. No. 4991, A. M. N. H.
Courtesy of the American Museum of Natural History.

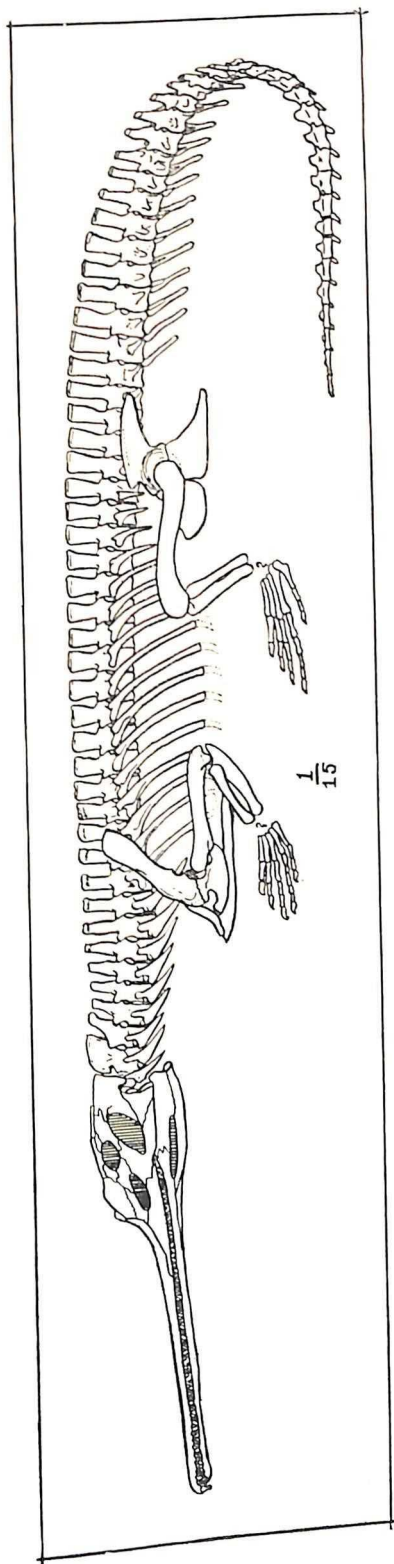


FIGURE 11.

Ruitodon carolinensis Emmons. Skeleton. One-fifteenth natural size.
Redrawn from McGregor. Courtesy of the American Museum of Natural History.

"The Phytosauria were more or less aquatic, inhabiting the fresh-water lakes and rivers of the Triassic period. Their remains are known in the Trias of Germany, England, and Scotland, eastern and western North America, India, and probably South Africa."

Clepsysaurus was further characterized by a long, gavial-like snout and slender conical teeth. Modern gavials of doubtless similar feeding habits are found in the large Indian rivers, and in the Malay peninsula, Sumatra and Borneo, and feed almost exclusively on fish.

The presence of *Clepsysaurus validus* at Simsbury implies the existence during early Newark time of a large river or fresh-water lake containing sufficient fish for the maintenance of animals some of which were about twelve feet in length.

Clepsysaurus (Rutiodon) manhattanensis (v. Huene)

Huene, F. v. 1913. Bull. Amer. Mus. Nat. Hist., xxxii, Art. xv, pp. 275-282, pl. xlix, text fig. 14 (*Rutiodon*).

Holotype.—Cat. No. 4991, American Museum of Natural History.

Locality.—Fort Lee, New Jersey, on the right bank of the Hudson river, opposite New York City.

Horizon.—Twenty feet below the thick sheet of basalt of the Palisades in a red sandy marl hardened by the overlying trap; hence near the base of the Newark series.

Original Description.—"The large plate of matrix (155×125 cm.) contains the pelvis, both hind legs without feet, small parts of the body and tail and a few dermal scutes (Pl. I) [Pl. VII].

"*Dorsal vertebrae*: There are 4 vertebrae belonging to the thoracic region as they possess relatively long diapophyses. The dorsal spines are but little lower than in *Rutiodon Carolinensis* (cf. MacGregor: Mem. Am. Mus. Nat. Hist., ix, 2, 1906).

"*Sacral vertebra*: A sacral vertebra without upper arch is lying near the abdominal ribs. It seems to be the first sacral vertebra because the sacral ribs are much weaker than those of the second sacral vertebra of *R. carolinensis* shown by MacGregor.

"*Caudal vertebrae*: 4 anterior caudal vertebrae and fragments are lying near to each other behind the pelvis. They possess very high and straight dorsal spines similar to those of *R. carolinensis*.

"*Hæmapophyses*: Remains of two hæmapophyses are visible; both of them lack the lower end. One of them is still attached to the penultimate tail vertebra by its articular facets, but most of the other parts are missing. The second specimen shows the articular facets divided as in all Parasuchians, which in contradistinction to those of dinosaurs are not connected by a bridge.

"*Ribs*: Beside the left tibia and fibula there are few thoracic ribs,

but no articular ends are preserved. Also the rib lying over the left pubis is a thoracic rib.

"Abdominal ribs: A large number of abdominal ribs are lying anterior to the pelvis. They are straight and slightly curved; several of them (6) are apparently of the median line and show a sudden curvature in lesser (for instance two on the side of the right femur) or greater (4 or 5 in the big mass) degree. They belong to the median and posterior part of the plastron. Two specimens below the sacral vertebra form a sharp angle and consist of two straight branches; they come from the most anterior part of the plastron.

"Ilium: Both ilia show their lateral aspect. The left ilium is partly covered by the proximal end of the left femur. The contour of the ilium is—except for the closed acetabulum—more similar to that of the Triassic Theropoda than to that of the European *Phytosaurs*, because it is lower and longer and at the same time possesses a sharp spine directed anteriorly. The ilium if compared with *R. carolinensis* shows the following distinctions: in *R. carolinensis* the contact line of the pubis at the lower border is relatively much shorter than in the recently discovered specimen. The length of this contact line in *R. carolinensis* is one third of the distance from the spina anterior to the spina posterior, but in this specimen only a little more than one half. The whole breadth of the acetabulum is nearly the same: the distance from the spina anterior to the spina posterior is one third longer than the width of the acetabulum in this specimen and one half in *R. carolinensis*. There is not much difference in the vertical breadth in the two species. The upper border in *R. carolinensis* is a little more curved and the posterior process a little narrower than in this species.

"Pubis: The left pubis is lying near the caput of the left femur, and the posterior process of the right ilium is above it. The bone shows the ventral face. The right pubis is near the lower border of the plate. The pubis of *R. carolinensis* is a good deal shorter as compared with the ilium, and compared with its own length it is broader than in the new species.

"Ischium: The left ischium is but little displaced near the left ilium and covers a small part of the right ischium; the latter shows the medial and this the lateral face. The whole bone is heavier and the posterior end broader than in *R. carolinensis*.

"Femur: The left hind leg lies near the abdominal ribs and the dorsal vertebræ, the right leg near the isolated pubis. The femur in its form (as the ilium) is similar to that of the Triassic Theropoda, only it is more curved. Its length is 43-44 cm. and it is the largest Parasuchian femur I have ever seen (*Mystriosuchus rütimeyeri* has a length of 40 cm.).

"Tibia and Fibula: The tibia is extraordinarily heavy as compared with all other Parasuchians. It is the same with the fibula which shows an S-like curvature. In the right leg the distal end of the fibula is lying near the proximal end of the tibia. The femur is but little

more than $1\frac{1}{2}$ times the length of the tibia (1.57 : 1.00). In *R. carolinensis* this relation is quite different (1.97 : 1.00).

"*Dermal scutes*: The dermal scutes are not very well preserved, but one can recognize the same type as in *R. Carolinensis* and the European *Mystriosuchus* which is quite different from *Phytosaurus*. In particular one scute of the tail is in fairly good preservation and shows the characteristic form.

"From this last similarity it is justifiable to conclude that the skull had a long and low snout.

"The comparison of the two specimens [that of Fort Lee and *R. carolinensis*] shows at least a specific difference. Therefore I propose to call the New York animal *Rutiodon manhattanensis* n. sp. The species described by Marsh as *Belodon validus* is based only on a fragment of a right scapula (Yale University collection No. 2056 [2138]). It is not adequate for the type of a species.

"The skull of *Rutiodon* has already been compared with European *Phytosaurs*, but not so the skeleton to any extent. *Rutiodon* and the European *Mystriosuchus* are hardly different, generically, and should probably be united in one genus, as I have already proposed some time ago, only the name *Rutiodon* dates from 1856 and is very much older than *Mystriosuchus*. Prof. E. Fraas very kindly gave me the opportunity of seeing all the remains of *Mystriosuchus* and *Phytosaurus* in the Stuttgart Museum. The skeletal difference between these two genera is very clear. The centra of cervical and dorsal vertebræ are shorter in *Phytosaurus* and the dorsal spines everywhere lower, especially in the anterior dorsal and anterior or entire caudal region. The whole construction of the vertebræ is higher in *Mystriosuchus* (the same in *Rutiodon*). The thickening of the upper end of the dorsal spines of the cervical, anterior dorsal, and anterior caudal vertebræ is greater in *Phytosaurus* than in *Mystriosuchus*, and the latter does not have any thickening at all of that part in the caudal vertebræ. In the anterior girdle the interclavicle has a different form in the two genera. In the posterior girdle most of the differences are in the ilium. The main difference in the femur is a strong curvature at the beginning of the distal third of its length in *Phytosaurus*; it is more curved than in any *Mystriosuchus* or *Rutiodon*. The difference in the dermal armature is sufficiently known.

"I should think *Rutiodon* and *Mystriosuchus* were better swimmers than *Phytosaurus* on account of their higher vertebræ (giving space for stronger musculature) and more compressed body. The slender-snouted *Phytosaurs* are the largest ones; *Mystriosuchus rütimeyeri* is the latest and at the same time the largest European form; but *Rutiodon manhattanensis* is the largest one I have ever seen."

It is quite evident from the foregoing description that the present species cannot be compared with *Clepsysaurus (Rutiodon) validus* (Marsh) as the two specimens do not include the same elements. Future discovery may prove their identity, in which event Professor Marsh's

name must take precedence, for although the type material is meager, the species seems to be sufficiently characterized to be valid.

DINOSAURS

Order SAURISCHIA

Suborder Theropoda

This group of reptiles includes two orders, Saurischia and Ornithischia; embracing in the first the carnivores, the Theropoda, and their derivatives, the huge, probably herbivorous Sauropoda; and in the second the predentate herbivores, which include the unarmored Orthopoda, the armored Stegosauria and Ankylosauria, and the horned Ceratopsia. Huene has advanced the idea that dinosaurs are diphyletic and that no relationship except a common ancestry, should be implied between the Saurischia on the one hand and the Ornithischia on the other (Huene 1908, Anat. Anz. Bd. xxxiii, pp. 401-405). The two groups are represented in the Newark fauna, both among the most primitive representatives of the orders; on the one hand the Theropoda represented by skeletons and a great abundance and variety of footprints, and on the other the herbivorous unarmored Ornithopoda whose presence is thus far betrayed by the footprints only and these of no very great variety.

The first evidence of the coming of dinosaurs to eastern North America is apparently in the footprints in the lower shales (Meriden series) of the Connecticut valley, and these are entirely of Theropoda, as the Ornithopoda are apparently not in evidence until after the last volcanic outflow of the upper trap sheet.

The suborder Theropoda may be thus defined (Zittel-Eastman):

"Carnivorous Dinosaurs with small cranium, the long axis of which is approximately at right angles to that of the neck. Margin of the jaws provided with laterally compressed, thecodont cutting teeth. Braincase incompletely ossified; antorbital vacuity large. Mandibular ramus without coronoid process, and usually pierced by a lateral foramen in its hinder half. Vertebral centra hollowed, the cervicals flattened in front and concave behind, post-cervicals amphiplatyan or slightly amphicœlous. Sternum unossified, acetabulum perforate. Pubes slender, projecting simply downwards, and united distally, like the ischia, in a symphysis which is often much extended. Post-pubic process not developed. Limb bones hollow, fore limbs considerably shorter than the hinder pair; digits three to five in number, provided with prehensile claws; hind feet digitigrade. Femur with inner trochanter; astragalus with ascending anterior process." Some of these features, however, were not perfected during Triassic time.

Two infraorders are represented by their osseous remains in the Newark rocks; the Cœlurosauria, including *Ammosaurus* and *Podokesaurus*; and the Prosauropoda, including *Yaleosaurus* and *Anchisaurus*.

Infraorder Prosauropoda

Family ANCHISAURIDÆ

Genus *Anchisaurus* Marsh

Marsh, O. C. 1885, Amer. Jour. Sci., (3) xxix, p. 169.

Generic History.—The name *Megadactylus* was given to the type species *polyzelus* by E. Hitchcock, Jr., in 1865 (Appendix [A]) at the suggestion of Sir Richard Owen and in allusion to the large first digit of the hand.

Marsh in 1882 (Amer. Jour. Sci., (3) xxiii, p. 84) substituted the term *Amphisaurus* for that of *Megadactylus* (preoccupied) in a classification of the Dinosauria which he offered. He may be quoted as follows:

"*Amphisauridæ*. Vertebræ biconcave. Pubes rod-like; five digits in manus and three in pes."

This term *Amphisaurus* is also used by Baur in 1882, p. 443, and in 1884, p. 447.

In 1885 (p. 169) Marsh proposed the name *Anchisaurus* for *Amphisaurus* which in turn proved to be preoccupied. He also stated that the family name should be *Anchisauridæ*, but no amended definition of the family was offered at this time. As this change was made before the description, though after the discovery, of the second species included under this genus, *Anchisaurus* (later *Ammosaurus*) *major* Marsh 1889, the generic name *Anchisaurus* could only refer to Hitchcock's *Megadactylus polyzelus* although no such specific reference was made by Marsh. *Anchisaurus* (*Megadactylus*) *polyzelus* (E. Hitchcock, Jr.) thus stands as the type species of this genus.

The last definition of the family *Anchisauridæ* given by Marsh is that in "Dinosaurs of North America" (1896 B, p. 239):

"Skull light in structure, with recurved cutting teeth. Vertebræ plane or biconcave. Bones hollow. Ilium expanded behind acetabulum; pubes rod-like and not co-ossified distally; no inter-pubic bone. Fore limbs well developed; femur longer than tibia; astragalus without ascending process; five digits in manus and in pes.

"Genera *Anchisaurus* (*Megadactylus*), *Ammosaurus*, *Arctosaurus* (?), *Bathygnathus*, and *Clepsyrosaurus*, in North America; and in Europe, *Palæosaurus*, *Thecodontosaurus*. All known forms, Triassic."

Later developments would eliminate from this list the non-dinosaurian *Arctosaurus*, also *Bathygnathus* which is a pelycosaur, and *Clepsyrosaurus*, a phytosaur.

The species may be discussed in their chronological order as follows:

Anchisaurus polyzelus (E. Hitchcock Jr.)

E. Hitchcock 1858, *Ichnology of New England*, pp. 186-187 (without a name).

E. Hitchcock, Jr. 1865, *The Ichnology Supplement*, p. 39, Appendix [A] (*Megadactylus*).

Cope, E. D. 1870, *Trans. Amer. Phil. Soc.*, xiv, p. 122 A, pl. xiii (*Megadactylus*).

Marsh, O. C. 1892, *Amer. Jour. Sci.*, (3) xliii, pl. xvi, fig. 3, pl. xvii, fig. 6 (*Anchisaurus*).

Marsh, O. C. 1896, *Din. of N. A.*, p. 147, pl. iii, figs. 4, 5 (*Anchisaurus*).

Huene, F. v. 1906, *Din. Aussereurop. Trias*, pp. 19-22, figs. 10, 10a (*Thecodontosaurus*).

Type specimen preserved in the museum at Amherst, Ich. Cat. No. 41/109-118.

Locality.—Water shops, U. S. armory, Springfield, Mass.

Horizon.—Longmeadow sandstone, from the upper (Portland) series of sandstones, etc., of the Newark beds.

Original Description.—This animal was originally described without a name, by E. Hitchcock (senior) as follows:

"The Springfield bones were discovered by William Smith, Esq., while engaged in superintending some improvements at the water shops of the United States Armory, which required blasting. He did not discover them till a large part had been taken away by the workmen. General Whitney, superintendent of the armory, very kindly ordered a re-examination of the fragments, and Mr. Smith obligingly presented me with whatever pieces could be found. These I put into the hands of Professor Jeffries Wyman, and just before he started for Surinam in February, 1857, he sent me the following statements in relation to these fossils:—

"With regard to the bones, I think that there can be no question that they are those of a reptile. This is shown by the configuration of the head, small trochanter, and a part of the shaft of a thigh bone, as well as by the imperfect caudal vertebræ; these last, however, are deficient in the concavo-convex bodies which are found in all scaly reptiles except the Enaliosaurians. Those from the sandstone are flat, or nearly so, on the ends, as in the Mammalia. The most remarkable feature, however, of the whole collection, is that of *hollowness*. This is carried so far, that but for the indications referred to, they might be referred to birds. Every bone except the vertebræ, and perhaps the small phalanges, is hollow. Nothing of the kind is known in Mammalia. While the bones from Springfield are as hollow as those of the Pterodactyle, I do not find that they are those of this animal; there is no positive proof of the long fingers, or of the broad sternum which these flying reptiles possessed. The remnants of the foot indicate that the toes were of disproportionate sizes, there being one large toe associated with three quite small ones; perhaps another existed, but there are

no signs of it. The claw of the large toe was very strongly recurved. The terminal phalanx of the other toes is deficient, so that we are uncertain even as to the number of the joints. The existence of the large toe in company with the small ones is in favor of a jumping animal.' " [Unfortunately, Professor Wyman apparently did not know that he was describing the hand and not the foot. R. S. L.]

In Appendix [A] of the Ichnological Supplement Doctor Edward Hitchcock, Jr., thus writes concerning this animal (pp. 39-40):

"Since the description of the bones on the 187th page of the Report on Ichnology was made, they have been shown to Professor OWEN, of the British Museum, London, and a few new points have been made out, by more thoroughly exposing them with a graver.

"Professor Owen very kindly gave his attention to the fossils during the limited time I was in London, and made his determinations concerning them, though 'subject to correction.' They are regarded by him as belonging to a 'Saurian Reptile with an unusually thin and compact wall of bone in the limb bones, which, however, might have been occupied by unossified cartilage, as in the young crocodile and turtle; but if they were filled with oil or light marrow, it would point to a course of development towards Pterodactyles or Birds. This phrase is purely hypothetical, and I mean to express no more than a degree of resemblance, supposing marrow and not gristle to have filled the large cavities.'

"The most important characteristics of these fossils so far as determining the genus is concerned, are in the bones of the right [fore] foot, which are tolerably well preserved, and a drawing of which—of the natural size, in Plate ix, fig. 6 [fig. 13]—has been made by my sister, Miss Emily Hitchcock. From this drawing it will be seen that the prominent character of the foot is the robustness of the pollex. Hence Professor Owen suggests the generic name *Megadactylus*. The only other termination possibly seen that there were no claws on any toe but the first one, were it not that among the fragments of the skeleton, another claw is preserved which is only about one-fourth the size of the one figured on the Plate.

"When the specimens were shown to Professors Owen and Wyman, it was thought that the foot was only four-toed, as a portion of the phalanges was covered by fragments of the rock. But close and careful work with the graver has uncovered the first and third phalanges of the fourth toe, seeming to show that the single phalanx on the right must have belonged to a fifth toe. Its greater size, also, shows that it could not have belonged to the fourth finger.

"In addition to the three phalanges of the fourth toe, a small bony knob was found, seeming to represent a fourth phalanx, or rudimentary claw. This, however, is so small, and the fragments of bone are so numerous throughout the rock, that it is possible it is only a bony fragment accidentally located in the position of a phalanx.

"For a specific name to this individual, I propose the name POLYZELUS, 'much sought for,' in allusion to the fact that for so many years other remains than simply tracks of the former inhabitants of the Connecticut valley, have been eagerly and anxiously sought for, and that now we have the much coveted bones."

Professor Cope's description, published in 1870, pp. 122A-G, follows:

"The remains consist of four caudal, and one dorsal vertebræ, the greater part of the left [right] fore foot with distal portions of ulna and radius; the greater part of the left femur, proximal end of left tibia, greater part of left fibula, tarsus and hind foot, including a tarsal bone, perfect metatarsus, proximal end of a second metatarsus, parts of the distal end of a third, and parts and impressions of four phalanges. Also, the greater part of both ischia. . . .

"*Vertebra.* A dorso-lumbar is much compressed, but not keeled below; the articular extremities are expanded, and their faces slightly concave. An anterior caudal [*vide infra*] has a similar form, but the extremities are plane. The posterior basis of the neural arch is on the posterior third of the upper surface, and the anterior end has evidently supported its anterior part. They leave the median third of the canal open laterally, its median surface passing into the external over a lateral shoulder. The arch probably bridged over this interval. The chevron bone is long and wide, and with thin walls. A second caudal exhibits similar characters. Two adjacent caudals in the same piece of matrix exhibit shorter, deeper centra, with strongly concave inferior surfaces, which are separated from the laterals by an obtuse longitudinal angle. Articular faces concave, forming vertical ovals truncate below. The chevron bones are narrower, directed

backward, and of very light construction. The neuropophyses present the singular character indicated above. Their contact with the cen-

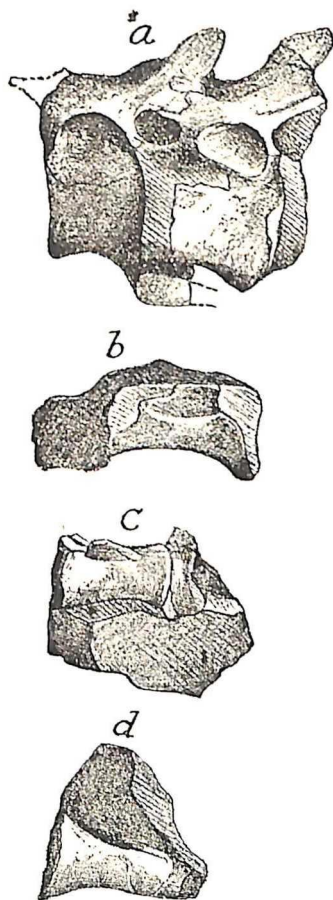


FIGURE 12.

Anchisaurus polyzelus (Hitchcock).
Vertebrae. Two-thirds natural size.
After Cope. a. anterior caudals;
b. sacral; c. posterior caudal;
d. dorso-lumbar.

trum is anterior and posterior only, their basis being excavated upwards into a regular arch, whose margins flare out a little. This remarkable structure is only paralleled in the sacrum of other Dinosauria, where the nerves destined for the sacral plexus, issue through huge foramina in the bases of the neurapophyses. Here the structure is continued on the caudals, and evidently for a very different purpose. The neural arch has a high longitudinal carina, which is continued in the neural spine. It is concave on each side between the zygapophyses. The posterior zygapophyses stand above an intervertebral space, and the narrow neural spine rises above them, as is usual in Dinosauria. The zygapophysial faces make about an angle of 45° . A distal caudal is slender, sub-cylindric, and with low neural arch.

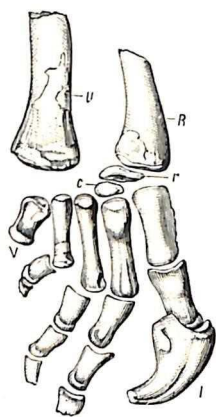


FIGURE 13.
Anchisaurus polyzelus
(Hitchcock). Right fore-
foot. One-half natural size.
After Marsh, c, centrale;
r, radiale; R, radius;
U, ulna; I and V, digits
one and five.

"The *right anterior foot* displays five digits, though one of them opposite the extremity of the ulna, was very short. The phalanges are, from without, 2-3-4-3-2; they are short and stout, the ungues short, deep, much curved and compressed. That of the interior digit is the largest: the inner edge is rounded, the superior broad and slightly flattened. At the middle of its length, a shallow groove near the dorsal outline begins to contract to a sharply defined, narrow groove, which continues to the end of the claw. The trochlear faces are well distinguished. The phalanges are stout and with a marked ligamentous pit on each side distally. The metacarpals of the two middle digits are slender and twice as long as the adjacent phalanges; that of the outer digit is one-third shorter, and that of the inner, one-half shorter than the median. The fourth metatarsus is longer than the external, but much more slender than any other. This finger was shorter than the third, and probably possessed three phalanges; portions of two are preserved, and the most distal is not ungual.

"The extremity of the ulna larger than that of the radius and rather more expanded. Both bones of the forearm are very pneumatic, and oval in section.

"The *femur* is represented by both extremities with shaft adjacent, and that part of the shaft supporting the third trochanter. It is peculiar in presenting a combination of characters. The proximal extremity resembles that of the Crocodilia, while the distal is truly Dinosaurian, approaching *Megalosaurus*. There is no distinct head, the whole extremity is compressed, and the extremital surface concave in its long axis. It overhangs the shaft on the inner side and forms a knob which is decurved, and contracts below abruptly to the shaft.

The external margin is a subacute ridge; the small trochanter is represented by a short ridge which is but little defined on the inner side, and which sinks to the general level some distance below the head. The compression of the shaft changes to a sub-cylindric form, and just above this point the large third trochanter projects. It is short; inside of it a large rugose surface indicates the insertion of a powerful muscle. Near the distal extremity the shaft is compressed transversely. The articular face of the condyles is rather flat. The outer has a continuous exterior face. The inner is divided exteriorly, near the posterior extremity, by a deep groove, which is continued obliquely forward and inward on the articular face. The anterior part of this condyle is strongly convex. The posterior is narrow and turned inwards and backwards to a sharp edge. This portion is outlined by the above mentioned groove, and forms a narrow ovate [*sic*] in section. The popliteal groove is quite deep, and the trochlear scarcely marked.

"The *tibia* and *fibula* are broken. Of the first, a piece of the proximal portion alone remains; of the latter, a piece is broken from the middle of the shaft. The head of the tibia is flattened by pressure. The spine or crest is very prominent, but not so much so as in *Laelaps*, and is much curved outwards. The posterior angle of the proximal extremity is prominent, and the prominence to which the fibula is applied marks the anterior third of the long diameter of the head in its present condition. The anterior crest gradually sinks to the shaft. The greater part of the latter is flat, as an impression in the matrix indicates. The fibula is slender and oval in section, with very thin walls. At the distal extremity it expands slightly; the articular face is plane transversely, and moderately convex antero-posteriorly. Proximally the shaft expands in the direction opposite to its compression, giving the head a nearly equal extent in both directions. The articular surface is directed obliquely downwards

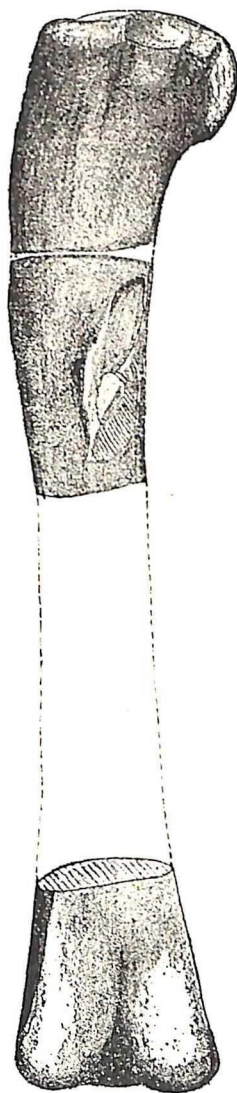


FIGURE 14.
Anchisaurus polyzelus
(Hitchcock). Femur.
Two-thirds natural size.
Modified from Cope.

to the tibia, and is more or less grooved; a strong rabbit extends round its posterior angle.

"The *foot* is in relation to the extremity of the leg, in a strongly flexed position. The tarsal and metatarsal elements were somewhat separated by the strain, though in nearly normal position.

"The *cuboid* bone alone remains of these. It is closely approximated to the fibula with a small interval occupied by matrix between. The form is somewhat like that in the genus *Alligator*, and it bears a similar relative size to the adjacent elements. It is a subtriangular piece with concave sides; the posterior angle, as it were, pinched. One lateral face, probably anterior, presents a longitudinal groove; one broad face, perhaps the external, a convex articular surface. The metatarsal face is slightly concave.

"The *metatarsus* which relates to the above, therefore the exterior, is much like that of the *Alligator*. The planes of the two extremities are nearly at right angles to each other. The proximal extremity is subtriangular with an external angle prolonged, and the posterior outline longest and slightly sigmoid. The shank has a large medullary cavity; the distal articular surface is sub-truncate, and the ligamentous pit very shallow, indicating absence of much flexure at that point. The convex external face of the cuboid, indicates the existence of a rudimental external digit in the usual place of the fifth; it may have been but a part of a metatarsus, as in the crocodiles. No trace remains. Two other digits have left their remains. Of these the median is so much larger than those on each side of it, as to render it probable that this animal possessed but three developed toes; in those types with a larger number, the two median at least, are of proportions more nearly similar to each other.

[Note. The foot probably contained three fully functional toes and one sub-functional hallux which would give the metatarsals the proportions noted by Cope. R. S. L.]

"One *phalange* of the middle toe is of a stout and somewhat compressed form. Two of the inner toe are more slender; the articular ligamentous pit is distinct in those of both, and the condyle convex, indicating extensive flexure. All are hollow.

"The disproportion between the lengths of the limbs is not readily ascertained; it is evidently not nearly so great as in the *Laelaps* [*Dryptosaurus*], perhaps not greater than in many modern *Lacertilia*.

"*Ribs* are represented by several fragments, one perhaps a half. They display both capitular and tubercular articulations, the former apparently much the more extensive. The head and shaft of the ribs are compressed, and the capitular prolongation is as deep as the base of the shaft. The latter has a groove along its dorsal line for the proximal two-fifths the length. It is hollow, the medullary cavity being equal in diameter to the wall surrounding it.

"A Y-shaped bone with rather long stem has left an impression.

The limbs of the figure are slightly unequal in length. Can it be a hatchet bone [rib] of the cervical vertebræ?

"The *pelvis* is only represented by a considerable portion of both ossa ischii. These indicate a remarkable peculiarity of the type, and explain the structure in *Laelaps* and some other Dinosauria. The portions preserved are the distal and median, with the impressions of the more proximal in the matrix. The former consists of two stout rod-like elements, having a triangular section, the superior and inner faces being plane, the exterior convex. The two interior are in contact throughout the straight portion of the bones. The extremity is convex and enlarged, especially downwards, and the two are separated by a deep groove, giving a section of the extremity the form of an ∞ . At the point of divergence the stylus is flattened, while the divergent portions are more flattened, at first horizontally, then with a gradual approach to vertically. Like the other bones, they are pneumatic and thin walled proximally; at their medial portion they contain very light spongy cancelli.

"As compared with *Compsognathus* the caudal vertebræ are very much shorter and deeper: the extremities are stouter and more robust; the metatarsi and phalanges with ungues being shorter and thicker. . . .

"No portion of the cranium or dentition of this genus has been preserved. The large stout hooked claws of the fore foot would indicate a more or less carnivorous diet."

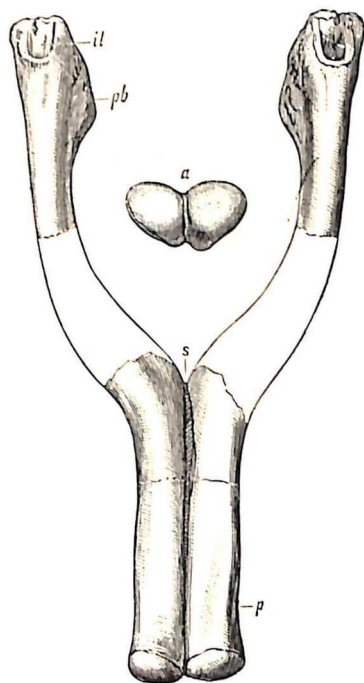


FIGURE 14a.

Anchisaurus polyzelus (Hitchcock).
Ischia. One-half natural size.
After Marsh. *a*, distal aspect; *il*, iliac facet; *P*, distal end; *pb*, pubic facet; *s*, symphysis.

Dimensions from Cope

Median caudal vertebra	21.5 mm.
Antero-posterior length	23. mm.
Depth, articular face	15. mm.
Width, articular face	34. mm.
Elevation of neural arch and spine	

Femur	
Length of proximal extremity	42.5 mm.
Width of proximal extremity	19. mm.
Diameter of shaft	21. mm.
Transverse width of condyles	40. mm.
External metatarsus	
Length	70. mm.
External metacarpus	
Length	11. mm.
Length of third metacarpus	25. mm.
" " second "	27. mm.
" " first "	23. mm.
Ungual phalanx; digit I	
Length	34. mm.
Proximal depth	17. mm.

Huene (1906, pp. 19-22) adds but little to the description offered by Cope as he only had Cope's figures for further study. He therefore contents himself with certain comparisons, notably with *Thecodontosaurus*, and a new interpretation of a few of the bones. The bone shown by Cope in fig. 6 [fig. 12] and described as an anterior caudal. Huene considers a sacral vertebra chiefly upon the ground of the length of its centrum and its difference of form from that of a typical anterior caudal. The two adjacent caudals in the same piece of matrix Huene thinks belonged near the beginning of the tail, but were not the foremost as the chevrons are too well developed.

To Cope's description of the hand Huene adds the presence of two carpalia, the smaller of which, lying above metacarpal II, he considers the trapezoid, and the larger a trapezium or radiale or intercentrum [centrale?]. The last interpretation he considers the most probable. Between the fifth metacarpal and the third digit lie three bones; the proximal one Huene considers only the distal fragment of metacarpal IV while the others he refers to as phalanges of digit V, which seems to me erroneous as they lie in position for those of digit IV, digit V being represented by the metacarpal only.

The ischia he considers similar to those of *Massospondylus*; they also resemble those of *Anchisaurus solus* in so far as common portions of each are preserved.

The femur as restored by Cope, Huene considers too long, and a sketch is inserted to show the proper length. (See fig. 14.) The fourth trochanter in position and character resembles that of *Thecodontosaurus*, but it also resembles that of *Yaleosaurus colurus* though the position on the shaft seems to be somewhat higher. There is however a break between the portion bearing the fourth trochanter and either end in the *polyzelus* femur, while the entire length of the proximal end in *Y. colurus* is not known; manifestly therefore the precise relative position of this trochanter in the two femora is a matter of conjecture.

Huene summarized the evidence as follows:

"These bones are similar in size to *Yaleosaurus colurus* and Marsh makes *Megadactylus* also another species of *Anchisaurus*. The distinction from *Anchisaurus* seems to me, however, greater than from *Thecodontosaurus*; although the dorsals are lengthened in the same manner as in *Anchisaurus*. The femur with its probably high situated trochanter IV, the form of the tibia and of the fibula, and the radius and the slender metacarpalia as well speak more for the relationship to *Thecodontosaurus*. It is shown also that the anterior caudals have small dorsal spines like *Thecodontosaurus*, while *Anchisaurus* according to Marsh has broad dorsal spines."

Here I think Marsh's restoration may be in error. In *Y. colurus* the caudals are unknown, that portion of the restoration being taken from *Anchisaurus solus*. In the latter what I should call the sixth or seventh caudal shows a neural spine even smaller than those in the *polyzelus* caudals. Anterior to this the caudal spines in *solus* are obscure, but, if the caudals of *polyzelus* were the third and fourth (and as they bear chevrons it seems likely), the dorsal spines could readily grade into ones similar to those of *solus* when the sixth or seventh caudal was reached.

Personally, I do not agree with Huene in removing *polyzelus* from *Anchisaurus* to the European genus *Thecodontosaurus*, thus far unreported from the American Triassic, though possibly ancestral to the American genus. Huene evidently overlooks the fact that *polyzelus* is the type species of the genus *Anchisaurus*, and, if his contention be correct, the name *Anchisaurus* becomes merely a synonym for *Thecodontosaurus* and the species *colurus* and *solus* are left without a generic name.

Genus *Yaleosaurus* V. Huene

Yaleosaurus (Anchisaurus) colurus (Marsh)

Marsh, O. C. 1891, Amer. Jour. Sci., (3) xlii, p. 267.

Marsh, O. C. 1892, Amer. Jour. Sci., (3) xliii, pp. 543-545, pl. xv, pl. xvi, figs. 1, 2.

Marsh, O. C. 1893, Amer. Jour. Sci., (3) xlv, p. 169, pl. vi.

Marsh, O. C. 1896, Din. of N. A., p. 148, pl. ii, figs. 1-3, pl. iii, figs. 1, 2, pl. iv.

Huene, F. v. 1906, Din. Ausereurop. Trias, pp. 6-13, pls. i-iii.

Huene, F. v. 1932, Die fossile Reptilordnung Saurischia. Mono. Geol., Pal. 1st Ser. Heft 4, p. 119, Taf. 54, fig 3 (*Yaleosaurus*).

Type specimen, Cat. No. 1883, Yale Museum.

Locality.—Manchester, Conn., in the quarry of Charles O. Wolcott, about one mile north of Buckland station.

Horizon.—High in the upper (Portland) series of sandstones, shales and local conglomerates, therefore geologically toward the close of Newark time.

Original Description.—"The new species is represented by perhaps the most perfect Triassic Dinosaur yet discovered, as the skull and greater portion of the skeleton were found in place, and in fine preservation. It is smaller than the specimen above described [*Ammosaurus major*], but similar in its general proportions, yet the two may be readily distinguished by the pelvic arch and posterior limbs. The pubes are distinct from each other, imperforate above, and the distal portions are only moderately expanded. The process that projects backward to meet the ischium is slender, and the face for union with that bone is quite small. The sacrum and ischia resemble those of *Ammosaurus* above described.

"The skull is of moderate size, and of delicate structure. In its general shape, it somewhat resembles the skull of *Hatteria*. The supra-temporal fossæ are very large, and the orbits especially so. The quadrate is inclined forward, and the upper and lower temporal arches are slender. Compressed, cutting teeth are present both in the pre-maxillary and maxillary bones. The lower jaws have similar teeth, and the rami are not united to each other at the symphysis in front.

"The vertebrae and limb bones are hollow, and the whole skeleton is lightly built. The neck is long, and the tail of moderate length [estimated, as it is not preserved. R.S.L.]. The scapula is elongate, and the coracoid very small and imperforate. The humerus has a strong radial crest, and the radius and ulna are nearly equal in size. There were five digits in the manus, the first, second, and third being armed with strong claws.

"The femur is longer than the tibia, and has a flattened head, somewhat like that of a crocodile. The tibia is short and stout, and the fibula well developed. The astragalus is not coössified with the tibia and the calcaneum is distinct. There were five digits in the pes, but only four functional, the fifth being represented by the metatarsal alone.

"The skull of this reptile is about five and one-half inches long, and the lower jaw four and one-half inches. The scapula and humerus are of equal length, each about six inches long. The femur is about eight inches in length, and the tibia about six. The animal when alive was about five and one-half feet long."

Subsequent Description by Marsh.—In 1892 (pp. 543-545) Marsh amplified the original description of this animal by the following details:

"The type specimen of this species, one of the most perfect Dinosaurs ever discovered, has now been worked out of the hard matrix in which it was embedded, and the skull and limbs are represented in the accompanying plates.

"The skull was somewhat crushed and distorted, but its main features are preserved, and its more important characters can be determined with certainty. In Plate xv, figure 1 [fig. 15], a side view is given, one-half natural size. One prominent feature shown in this

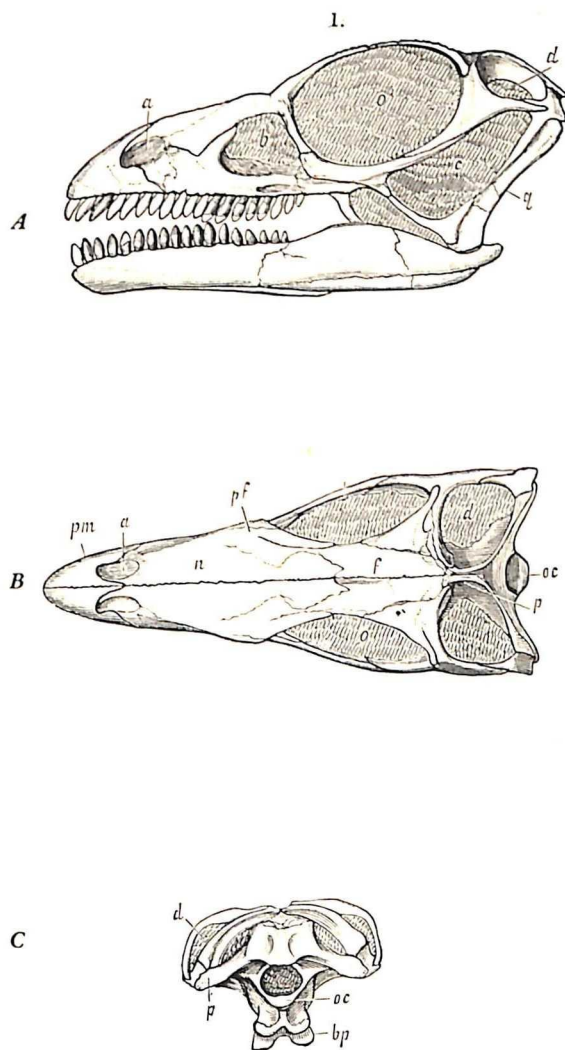


FIGURE 15.

Yaleosaurus (Anchisaurus) colurus (Marsh). Skull.
One-half natural size. After Marsh. A, left side view;
B, dorsal view; C, posterior view, a, nasal opening,
b, antorbital fenestra, bp, basipterygoid process, c, infra-
temporal fossa, d, supratemporal fossa, f, frontal, j, jugal,
n, nasal, oc, occipital condyle, p, paroccipital process,
pf, prefrontal, q, quadrate.

view is the bird-like character of the skull. The nasal aperture (*a*) is small, and well forward. There is a large antorbital opening (*b*), and a very large orbit (*o*). This is elongated oval in outline. It is bounded in front by the prefrontal, above by the same bone, and a small extent of the frontal, and further back by the postfrontal. The postorbital fossa (*d*) is large, and somewhat triangular in outline. The infratemporal fossa is quite large, and is bounded below by a slender quadratojugal. The quadrate (*q*) is much inclined forward. The teeth are remarkable for the great number in use at one time. Those of the upper jaw are inclined forward, while those below are nearly vertical. The lower jaw has the same general features of this part in the *Theropoda*.

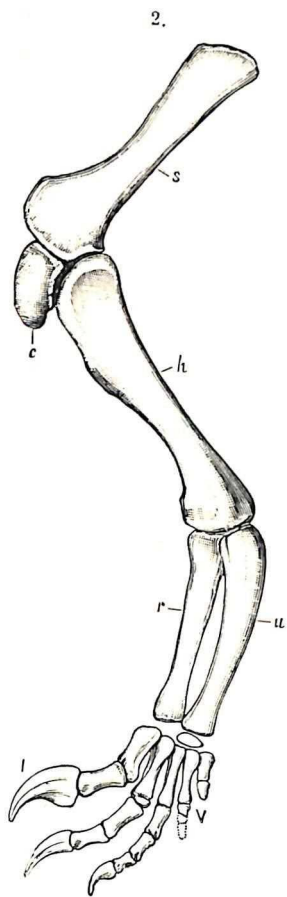


FIGURE 16.
Yaleosaurus (Anchisaurus) colurus
(Marsh). Left fore-limb. One-fourth
natural size. After Marsh. *c*, cora-
coid; *h*, humerus; *r*, radius; *s*, scapula;
u, ulna; *I*, digit one (pollex);
I', digit five.

"In Plate xvi, figures 1 and 2 [fig. 15] the same skull is shown, also one-half natural size. The top of the skull, represented in figure 1 [fig. B], is considerably broken, and this has made it difficult to trace the sutures, but the general form and proportions of the upper surface are fairly represented. In figure 2 [fig. C] only the back portion of the cranium is shown. The foramen magnum is remarkably large, and the occipital condyle is small and oblique. The basiptyergoid processes are unusually short.

"The neck vertebræ are long and slender, and very hollow. Their articular ends appear to be all plane or slightly concave. The trunk vertebræ are more robust, but their centra are quite long. The sacra appear to be three in number.

"The scapular arch is well preserved. The scapula, shown in Plate v, figure 2, *s* [fig. 16], is very long, with its upper end obliquely truncated. The coracoid (*c*) is unusually small, and imperforate. The sternum was of cartilage, some of which is preserved. The humerus (*h*) is of the same length as the scapula, and its shaft is very

hollow. The radius and ulna are also both hollow, and nearly equal in size.

"There is but one carpal bone ossified in this specimen, and this is below the ulna. There were five digits in the manus, but only three of functional importance, the first, second, and third, all armed with sharp claws. The fifth (V) was quite rudimentary. The fore foot of the type species of *Anchisaurus* [*polyzelus*] is shown one-half natural size, on Plate xvi, figure 3 [fig. 13].

"The pelvic bones are shown in figure 3 of Plate xv [fig. 17]. The ilium (*il*) is small, with a slender preacetabular process. The ischia (*is*) are elongated, and their distal ends slender, and not expanded at the extremity. The pubes (*p*) are also long, imperforate, and not coössified with each other. The anterior part is a plate of moderate width. The ischia of the type species of this genus are shown on Plate xvii, figure 6.

"The femur (*f*) is much curved, and longer than the tibia (*t*). The latter is nearly straight, with a narrow shaft. The fibula (*f'*) when in position was not close to the tibia, but curved outward from it. All these bones have very thin walls. The astragalus (*a*) is small, closely applied to the tibia, and has no ascending process. The calcaneum (*c*) is of moderate size, and free. There are only two tarsal bones in the second row.

"The hind foot has four functional digits, all provided with claws. The fifth was represented only by a rudiment of the metatarsal (V). The first digit was so much shorter than the second, third, and fourth, that this foot would have made a three-toed track very much like the supposed Bird-tracks of the Connecticut River sandstone."

In a paper entitled "Restoration of *Anchisaurus*" published in the *American Journal of Science*, (3) xlv, 1893, pp. 169-170 and plate vi, Professor Marsh throws additional light upon this interesting animal and its relatives by one of the admirable restorations which redound so much to his credit. This restoration is supposed to be that of the species under discussion, though, as the tail and part of the neck vertebræ were lost before the importance of the specimen was realized, such parts are supplied mainly from the smaller *Anchisaurus solus* and from *Ammosaurus major* as well. Marsh says:

"The restoration . . . on Plate vi [fig. 18] indicates that [*Yaleosaurus*] *Anchisaurus colurus* was one of the most slender and delicate dinosaurs yet discovered, being only surpassed in this respect by some of the smaller bird-like forms of the Jurassic. The position chosen is one that must have been habitually assumed by the animal during life, but the comparatively large fore limbs suggest the possibility of motion on all four feet. The compressed terminal digits of the fore feet, however, must have been covered by very sharp claws, which were used mainly for prehension, and not for locomotion.

"The small head and bird-like neck are especially noticeable. The ribs of the neck and trunk are very slender. The tail apparently

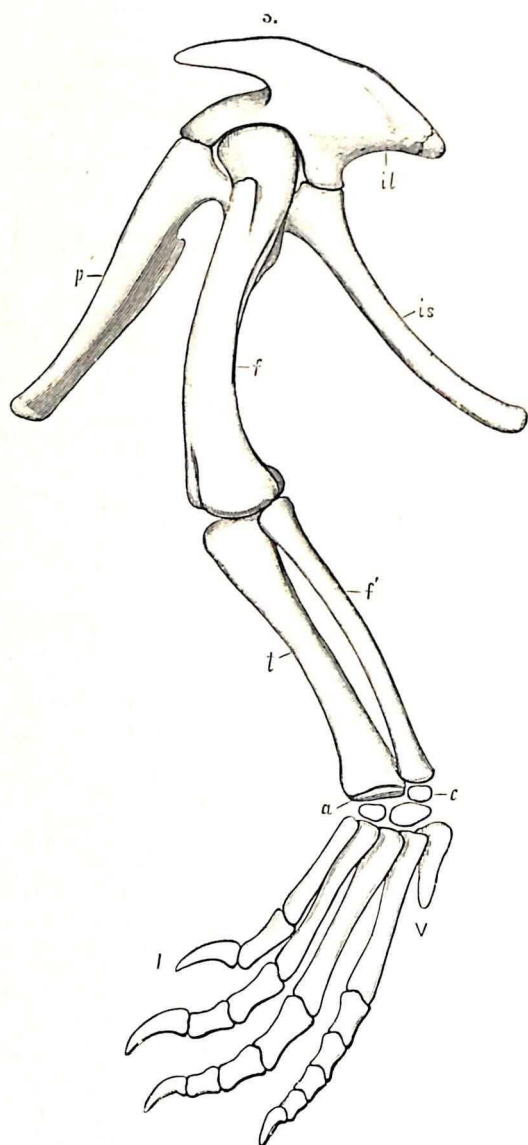


FIGURE 17.
Yaleosaurus (Anchisaurus) colurus (Marsh).
 Left hind-limb. One-fourth natural size.
 After Marsh, *a*, astragalus; *c*, calcaneum; *f*, femur;
f', fibula; *i*, ilium; *is*, ischium; *p*, pubis; *t*, tibia;
I, digit one (hallux); *V*, digit five.

differed from that of any other dinosaur hitherto described, as it was evidently quite slender and flexible. The short neural spines and the diminutive chevrons directed backward indicate a tail not compressed, but nearly round, and one usually carried free from the ground."

Marsh's description was amplified greatly by Huene (1906, pp. 6-13, pls. i-iii), who published an excellent series of photographs of all of the Connecticut dinosaurian types.

Discussion of Von Huene's Genus Yaleosaurus.— Von Huene in 1932, p. 119, emphasizes certain characters of *Anchisaurus colurus* which in his estimation remove it from the genus *Anchisaurus*, and he proposes for it a new genus *Yaleosaurus*, named in honor of the great institution from which it was first made known.

If the type species *Anchisaurus polyzelus* is removed to the genus *Thecodontosaurus* the name *Anchisaurus* must be eliminated entirely and *A. colurus* and *A. solus* must either be removed to other genera or provided with new names. This Von Huene has done, making *colurus* the type species of the new genus *Yaleosaurus* and removing *A. solus* to *Ammosaurus*, making it thus congeneric with *Ammosaurus major*.

Professor Romer, in the second edition of his *Vertebrate Paleontology*, 1945, p. 239, places *Yaleosaurus* in the infraorder Prosauropoda, based upon several criteria as follows:

"The first step in sauropod development is perhaps illustrated by *Yaleosaurus* [*Anchisaurus colurus*] of the Upper Triassic of North America. This was a small dinosaur (the largest specimen was but 7 or 8 feet long) and many of the bones were still hollow in coelurosaur fashion. There are many suggestions, however, of sauropod relationships. The teeth were comparatively blunt and straight; and the jaw was short, the quadrate slanting forward as well as down to reach the jaw articulation; these are sauropod features. Highly suggestive is the persistently primitive construction of the limbs. Despite the small size of this animal, the hind legs were comparatively short and clumsy and the metapodials were not greatly elongated . . . While the fifth toe had been reduced, the other four were all well developed; and the hallux was not, as in the majority of carnivores, turned back and separated from the three middle digits."

The actual specimens of *Yaleosaurus* and *Ammosaurus major* seem as well to bear out this statement. Metatarsal I has a position parallel to metatarsal II in the rock and the hallux lies alongside of the other digits, yet the numberless footprints which have evidently been made by dinosaurs of this type show no trace of the claw imprint alongside those of the other digits, but always, when an imprint of the claw is present, it lies some distance to the rear of the foot (see figures 38-40).

"The front legs were comparatively little shortened; they were still about two-thirds the length of the hind limbs and were strongly built. The fifth digit in the hand . . . was considerably reduced,

and the fourth reduced to some extent as well. Probably these forms were not purely bipedal in habits and retained the possibility of walking on all fours."

Again the negative evidence of the presumed footprints refutes this.

Further Description.—*The skull.* The skull is nearly complete though quite badly crushed, nevertheless the limitations of most of the bones can be clearly distinguished though their position in relation to each other is only approximate. Huene published two photographs of the skull which purport to be natural size; in reality the length of the printed figure is 5.5 mm. too short. The figures are overlain by a transparent key for the identification of the bones which, while admirable, seems erroneous in indicating what is apparently the left frontal as the right. The anterior part of what Huene calls "Præfrontale sinistræ von innen" is the inner surface of the same bone he calls the lachrymal in the view from the left side. What he calls the left frontal is a slender process of bone which is seemingly continuous with the posterior portion of the prefrontal.

The premaxillæ are both fairly well preserved and not far removed from their normal position. Posteriorly each embraces a portion of the narial opening, which is oval with its long axis nearly parallel to the margin of the jaw. The hinder process for articulation with the maxilla is acuminate. But one premaxillary tooth is preserved, and in the present condition of the skull the number of dental alveoli is not discernible, though Marsh has restored seven teeth in the premaxilla. The length of this bone on the right side is apparently 19 mm.

The maxilla extends from about the mid-length of the narial opening to beyond the posterior border of the antorbital fenestra. Anteriorly it sends a process forward above the premaxilla which bounds the lower posterior half of the nares. Dorsally it is broadly notched for articulation with the nasal bone which, however, is not preserved. The maxillary is extended posteriorly forming the lower limitation of the antorbital fenestra, sending inward the shelf-like floor to the fenestra as in *Allosaurus*. There is also evidence of a foramen piercing this inturned portion at the anterior angle of the fenestra as in *Allosaurus*. The number of maxillary teeth was eight to nine (Huene), though in Marsh's restoration twelve are shown. These have a broad lanceolate form with somewhat constricted cervix and rounded cutting edges which show no sign of crenations. The premaxillary tooth preserved is very suggestive of those of certain Sauropoda, and none of the teeth gives evidence of the terribly aggressive carnivorous habits of the greater megalosaurs. The length of the right maxillary is 46 mm. and its depth as preserved 22 mm. The orbit is bounded below by the jugal, a slender triradiate bone, the ascending process of which articulates with the postorbital, while its posterior process, the preserved portion of which is extremely short, should reach a forward branch of the quadratojugal. Anteriorly the jugal articulates with the maxillary and according to Huene with the lachrymal as

well, the latter forming the limitation between orbit and antorbital fenestra. The greatest length of the jugal as preserved is 34 mm.

The postorbital is another triradiate bone, this time with the three processes of nearly equal length. The antero-dorsal articulates with the well developed postfrontal by a long contact suture on its anterior margin and then continues on to articulate with the parietal, forming thus apparently all of the anterior limit of the supratemporal fenestra. The posterior process of the postorbital defines in like manner the inferior boundary of the supratemporal and the superior limitation of the infratemporal fenestra. Posteriorly this process fits into a notch between two forwardly directed processes of the squamosal, the combined structure forming the supratemporal arcade. Of the postorbital the greatest antero-posterior diameter is 40 mm. while the greatest dorso-ventral dimension is 34.5 mm.

The roof of the skull should show five pairs of bones. Of these I recognize but vague traces of the nasals. The prefrontals are ill defined, but on the left side there is preserved a portion of bone which forms the anterior half of the superior limitation of the large orbit, articulating in front with the lachrymal and dorsally with the frontal. The greatest dimension of this bone, its length, seems to be 28.5 mm.

The frontals show a considerable expanse, differing in this respect from the slender character of most of the other bones of the cranium. That of the right side is nearly gone, while the left appears fairly well preserved except at its posterior end. It bounds the orbit little if at all, for the prefrontal extends nearly if not quite to the forward limit of the postfrontal. Its anterior margin is notched for the reception of the nasal bone, the apex of the notch being very near the mid-line of the skull. Posteriorly the frontal is destroyed. Whether it came in contact with the parietal of its side as Marsh shows or whether the postfrontal intervened I am not sure, but the better preserved postfrontal, that of the right side, seems to have met its fellow in the mid-line of the skull. The dimensions of the left frontal are: length as preserved, 26 mm., breadth, 7 mm.; of the postfrontal, greatest length, 27 mm.

The parietals are curiously curved bones nearly horizontal at their anterior end and twisted on their long axis through an angle of more than 90° so that the posterior face is visible from above. Anteriorly they articulate with the postorbitals and posteriorly with the supraoccipital while their externo-posterior portion articulates with the squamosal. Of course they form the inner limitations of the supratemporal fossæ. Their greatest length is about 33 mm., while from the middle line to the externo-posterior angle is about 19 mm.

Posteriorly the skull shows the occipital complex in articulation, except the left exoccipital which is displaced. The basisphenoid is approximately in position, though it seems to be bent upward on its longitudinal axis so as to pull the articulation with the basioccipital tubera somewhat apart. The occipital condyle is composed of a median basioccipital element and a lesser lateral portion from each of the

exoccipitals. The latter show a number of foramina which Huene (1906, pp. 6-7) has identified as follows:

"The exoccipital process broadens at its base into three folds, one of which goes to the condyle. The second, really a branch of the first, is small and sharp and goes downward toward the tubera. Between these two first folds are found two foramina, one, somewhat larger, above in the angle of the fold, and one, somewhat smaller, beneath on the small fold; these two I consider the foramina hypoglossi (XII). . . . The third fold is the chief ridge of the exoccipital process and is broad and strong. Between this and the second fold is found the large opening of the foramen lacerum and the foramen jugulare, and before this broad fold the opening of the canalis Fallopii (N. facialis, VII) must have been found as is the case in *Plateosaurus*."

The quadrate and squamosal are well developed, and the former is directed obliquely downward and forward as in Marsh's restoration, not vertically as in that of Huene (p. 10). The lower jaw is typical of the Theropoda and bore apparently eighteen teeth. There is no trace of the usual aperture through the surangular.

Vertebral Column.—There are preserved eighteen presacral vertebræ, including two anterior cervicals which lay in the rock very near the skull. These are elongated, with low neural spines and strongly extended zygapophyses the articular facets of which lie nearly parallel with the longitudinal axis of the bone. The length of neither vertebra is preserved entire, but the anterior of the two now measures 37 mm., the posterior 56 mm. The centrum in each case is extremely hollow, the walls of the posterior one measuring 1.5 mm. thick. Long, slender cervical ribs, almost like those of *Compsognathus*, lie beside the centra and parallel to their long axis. The anterior one and a half vertebræ in the larger block Huene considers cervicals, and the following eleven dorsals, after which come three vertebræ concealed by the pubes before one comes to the first sacral, making fourteen dorsals altogether. Of these the anterior dorsals are shorter than the cervicals, but they again increase in length until the eighth, of which the centrum is 45 mm. long, after which they diminish again, the eleventh, which is the last visible one, being but 37 mm. long. These vertebræ are hour-glass shaped, for while the ends of a centrum measure 22 mm., across its middle section it is but 10 mm. broad.

The neural spines of the dorsal vertebræ are low and rectangular and that of the seventh measures 29 mm. long and about 15 mm. high. The centra show a longitudinal depression on either side which lightens them somewhat.

Marsh's estimate shows twenty-two presacral vertebræ as indicated by the numbering on the type specimen.

The ribs are long and slender, tapering to a very delicate extremity. The proximal end on the contrary is well developed, and so far as the ribs are exposed the capitulum seems always to articulate with

the centrum of the vertebra, not rising onto the transverse processes as in some dinosaurs, notably *Stegosaurus*. The longest rib, that of the sixth vertebra, measures 206 mm. in length.

Appendicular Skeleton.—The scapula of the left side is complete but seems to have a somewhat greater curve than in life. The proximal end is broadened, yet not markedly so when compared with later types, and the distal end shows a slight expansion, the posterior angle being distinctly acuminate. The length of the scapula measured on the curve is 147.5 mm., on the chord 123.7 mm., the proximal breadth 45.7 mm., that of the distal end 31.8 mm.

The coracoid is quadrilateral, somewhat thickened at its rounded postero-ventral angle. It shows no trace of coracoid foramen. Its length is 46 mm., its depth about 27 mm.

The humerus is broadened proximally and distally but the distal end especially is very thin. Neither the right nor the left is entire, the one showing the distal, the other the proximal end. Huene estimates the length from 180 to 190 mm. The width of the proximal end is 56 mm. while that of the distal end measures 48 mm. The radius is slender and the ulna broadened and the bones lie across one another in the rock. The distal end of the radius, however, seems displaced. The length of the radius is 92 mm., of the ulna 105 mm. At the distal end of the ulna lies a small ovoid carpal bone, probably the ulnare.

The hand is a splendid prehensile organ, especially in the power indicated in the first digit, the claw of which was large and sharply curved, and the entire finger shows evidence of great range of movement. The second and third digits are progressively more slender. Length of hand about 90 mm.; length of the first ungual phalanx 4.5 mm., its greatest breadth 2.2 mm.

The pelvic girdle is represented by the right ilium and both pubes; of the former only the acetabular portion with its two peduncles is exposed. In the restoration of *Yaleosaurus* (*Anchisaurus*) by Marsh is substituted the ilium of *Ammosaurus*, which Huene criticizes on the ground that it should resemble more nearly that of *Thecodontosaurus*. The antero-posterior breadth of the acetabulum measures 53 mm.

The pubis, Huene says, resembles partly that of *Plateosaurus* and partly that of *Megalosaurus*. The proximal end shows a distinct hook-like process, a rather narrow neck, beyond which the bone expands to a breadth of 50 mm. The distal end is somewhat thickened, but in common with other Triassic forms does not show the foot-like fore and aft expansion of the later Theropoda. The length of the right pubis is 183.5 mm., its proximal breadth 41.5 mm., the width of the neck-like portion 15 mm., and of the distal portion 30 mm.

The right hind limb is entire with the exception of the head of the femur, and is exposed on its posterior aspect, including the entire plantar surface of the foot.

The fourth trochanter of the femur is prominent and is situated 123.5 mm. from the distal end. The femur shows a distinct sigmoid

curve and the distal condyles are well developed. The femoral length as preserved is about 210 mm., breadth of shaft 22.5 mm., of distal end 41.5 mm.

The tibia and fibula lie perpendicular to the bedding plane (the animal being supine) and seem to show a marked shortening due to pressure. It may well be that the bowing out of the fibula mentioned by Marsh is partially due to the same cause though *solus* shows it to some extent as well.

Tibial length including astragalus 14.7 mm.; breadth of proximal end 38.5, of distal end 43.5 mm. Length of fibula 127.7 mm. The flat astragalus, which has no ascending process, is closely applied to the distal end of the tibia, while the calcaneum is a much smaller, somewhat rounded bone.

Of the distal row of tarsalia two are preserved, which Huene identifies as the cuboid lying near metatarsal V, and the cuneiform III near metatarsal III. The foot is well developed and compact, and, while the hallux lies in the same plane as the other digits in the rock, if one may judge from the probable footprints, it was in life rotated to the rear so as to oppose the remaining digits as a powerful grasping claw. Metatarsal V is reduced to about one-half its functional length. Length of metatarsal III, 98 mm.; of digit III, 105 mm.

Lull has correlated the footprint known as *Anchisauripus sillimanii*¹ with the species of dinosaur under consideration, for both track and length of stride are just what the proportions of *Anchisaurus* (*Yaleosaurus*) *colurus* would lead one to expect. The footprint is one of the most common known in the Connecticut valley, and the species of dinosaur is the only one known from more than one specimen, as I have identified that found in 1818 at East Windsor (*vide supra* p. 60) as the same species. The latter specimen does not, however, add materially to our knowledge of the animal as it is far less complete than the type specimen.

Yaleosaurus colurus was an alert, active dinosaur, preying upon the smaller vertebrates of his generation, as the powerful grasping claws and well developed teeth imply. While the actual remains are confined to the close of the Newark deposition in the Connecticut valley, the correlated footprints, being found first in the upper (posterior) shales, imply a longer career, though possibly not in the ultimate stage of evolution in which we know it. I believe the animal to have been entirely bipedal, never bringing the fore limbs to the ground even though their relatively large size would seem to imply it, for the imprint of the hand would be unmistakable and I have never seen in conjunction with the presumed footprints of *Yaleosaurus* or elsewhere such an impression. On the other hand, the imprints of the manus in the plant-eating ornithopod dinosaur tracks are fairly common, but imply a hand of a totally different character from that of *Yaleosaurus* resembling much more closely that of *Camptosaurus* of the Morrison, a well known predentate.

¹Of this there is an element of doubt, however.

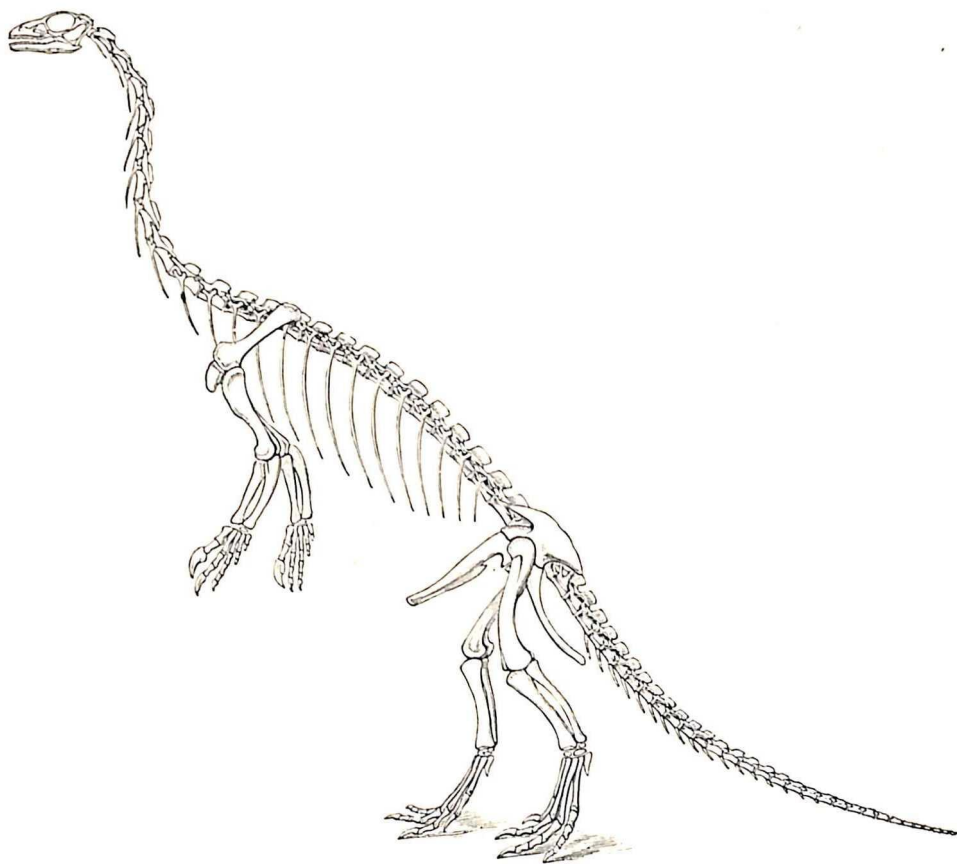


FIGURE 18.

Yaleosaurus (*Anchisaurus*) *colurus* (Marsh). Restoration of skeleton.
One-twelfth natural size. After Marsh.

Restoration of Yaleosaurus colurus.—The very well known restoration by Marsh (fig. 18), which has had wide acceptance in text-books and other publications, presents but few points to which in our more exact knowledge of the dinosaurs as living beings one can take exception. As the most salient point for criticism I would mention an apparent disproportion of limbs in that the fore limbs seem to be drawn slightly too great in size. There are also twenty-three presacral vertebrae, giving to the dorsal series one more than the two type specimens of *Yaleosaurus* (*colurus*) and *Anchisaurus* (*solus*) seem to show. The correction of these errors would tend to reduce in a measure the apparent top-heaviness for a bipedal gait. The tail seems somewhat short, though of this there is no true evidence other than analogy, for a long, slender tail and a short, heavy one may be equally efficient as a

counterpoise, and the former is the type found in cursorial lizards, notably the bipedal ones (see also *Podokesaurus*, *infra* p. 137).

The tail also passes much too near the ischia at their distal end, a condition which would allow no room for a pelvic outlet for egg-laying or the evacuation of the alimentary canal.

The neural spines of the caudal vertebræ are restored like those of the presacral vertebræ. The evidence of the tail of *Anchisaurus solus* implies that they were quite small and low, a short distance from the proximal end of the tail. The final point of criticism is in the position of the hallux to which allusion has already been made.

I offer as a substitute a new restoration made in the form of a model in the round, one side of which displays the skeleton, the other the animal in the flesh, an old idea but newly applied in prehistoric restorations in the hope that thereby the number of errors of interpretation would be reduced. Photographs of this model (Plates iv and x), which is one-third linear dimensions, are here presented for comparison with the classic restoration by my predecessor.

Anchisaurus solus Marsh

Marsh, O. C. 1892, Amer. Jour. Sci., (3) xliii, p. 545.

Marsh, O. C. 1896, Din. of N. A., p. 149.

Huene, F. v. 1906, Din. Aussereurop. Trias, pp. 14-15, pl. iv.

Huene, F. v. 1932, Mon. Geol. u. Pal. Ser. I. Hft. 4, p. 27, pl. 49 fig. 1 (*Ammosaurus*).

Type specimen, Cat. No. 209, Yale Museum.

Locality.—Manchester, Conn., from quarry of Charles O. Wolcott.

Horizon.—Upper (Portland) series of sandstones, shales and local conglomerates, about two feet higher and fifteen feet south of *Yaleosaurus colurus*.

Marsh's original description is as follows:

"A fortunate discovery has recently brought to light almost the entire skeleton of a diminutive Dinosaur, which may be referred to *Anchisaurus*, but clearly belongs to a distinct species. It was found in nearly the same horizon as the remains above described [*Y. colurus*], and in the immediate vicinity, so there can be little doubt that it was a contemporary. The skeleton is imbedded in a very coarse matrix, so difficult to remove that the investigation is only in part completed. The portions uncovered show the animal to have been about three feet in length, and of very delicate proportions. The bones of

the skeleton are almost all extremely light and hollow, but most of them are in fair preservation.

"The skull, so far as it can now be observed, resembles the one just described. The teeth are numerous, and inclined forward. The orbit is very large. The quadrate is inclined forward, and the lower jaw is robust. The entire skull is about 65 mm. in length, and the lower jaws the same.

"The neck was very long and slender, the first five cervicals measuring some 80 mm. in extent. The dorsals are also elongated, the last six covering a space of 135 mm. The number of vertebræ in the sacrum cannot yet be determined. The caudal vertebræ are short, the first ten occupying a space of 140 mm.

"The humerus has a very large radial crest, and is 66 mm. in length. The rest of the fore limb, so far as made out, is similar to those in the species described. The tibia is about 88 mm. in length. There were five digits in the hind foot, but the fifth is represented only by the rudimentary metatarsal. The animal when alive was about as large as a small fox."

Further Description.—The skull fragments, still embedded in the matrix are of so very fragmentary a character that I can add practically nothing to what Professor Marsh has said; indeed it is difficult even to verify all his statements. The dimensions he gives are correct.

The vertebral column shows apparently twenty-two elongated vertebræ, which together with the atlas make twenty-three as the total number of presacrals; of these Huene reckons nine as cervicals and fourteen as dorsals. The cervicals are extremely long and slender though apparently similar in proportions to the two anterior cervicals of *Y. colurus* which are preserved. For the most part only the ventral aspect of the vertebral centra is visible with the exception of the anterior or four or five cervicals, and they are so vaguely outlined as to be hardly describable. They seem, however, to resemble those of *Y. colurus* above referred to in the elongated zygapophyses and vestigial neural spine. The posterior cervicals at least and the anterior one or two dorsals show lateral longitudinal keels demarking the limits of lateral ventral walls; in the other dorsals the keels become obsolete and the centra are more rounded. As in *Y. colurus* the anterior dorsal (10th presacral) is shorter than the cervicals, beyond which the dorsals increase somewhat in length, the longest being the 9th (18th presacral) with a length of 21 mm. The 12th dorsal measures 20.5 mm. long by 9 mm. wide at the articular ends of the centrum and 5.5 mm. broad in its central portion, showing the typical contracted form seen in *Y. colurus*. The ribs are exceedingly slender yet their length would indicate a full-bodied animal. The greatest preserved length, that of the 5th dorsal, is 85.5 mm. The sacrum unfortunately cannot be seen in the greatest degree of preparation which the specimen will safely bear, but the anterior ten (Marsh) caudals are visible on the lower side of the block. As I have said in discussing the relationship of *A. polyzelus*.

the shape of the neural spines resembles those of that species and is not of the character figured in Marsh's restoration of *Yaleosaurus*. The centra are shorter than those of the dorsal vertebrae, that of the sixth measuring 17 mm. in length, while the seventh is 16 mm. long by about 15 mm. high including the neural spine. The caudal centra seem somewhat compressed laterally. This may in a measure be due to crushing.

Appendicular Skeleton.—Of the shoulder girdle but a trace is present, an indefinable fragment of what may have been the left scapula hidden beneath the bulk of the humerus. The latter is well preserved on either side, especially the left, and is particularly notable for the relatively high, almost bird-like proximal end with its expanded processus lateralis which narrows to a rather robust shaft, to dilate again at the distal extremity. The length of the left humerus is 67 mm., its proximal breadth 25 mm., width of shaft 6 mm., of distal end about 15 mm. As Huene says, it is short, but in comparison with the slender vertebrae is very robust and gives indication of a well developed musculature. The radius and ulna are also well developed. They lie in position, parallel to each other, the ulna being somewhat curved. Their length seems to be about 37 mm. In Marsh's statement that the hand had five digits of which the fifth is represented by the rudimentary metatarsal he must have reasoned from analogy, basing his description upon *colurus* and *polyzelus*, for the present specimen shows but one slender metacarpal, doubtless the fourth, beyond which lie portions of two phalanges, and toward the radial side of the hand the vestige of another phalanx, possibly ungual. There are rather vague impressions in the coarse rock which may have lodged other bones, but not sufficient in number or position to complete the manus as described by Marsh.

Of the pelvic girdle the right ilium is preserved together with both ischia, which, however, lack their extremities, and plate-like expansions which represent the pubes—all in their natural relative position.

The ilium is almost complete in outline. The entire acetabular outline for a chordal distance of 245 mm. is exposed. In front the ilium shows the long slender anterior process which Marsh considers characteristic of the family, but posteriorly the end is broken away so that the bone appears rounded. The dorsal outline of the bone is not preserved. So far as it goes this ilium agrees perfectly with that in Marsh's restoration of *Yaleosaurus*, in spite of Huene's contention that that of *Ammosaurus* was used as a model. It may have been in part, but no one can disprove the correctness of the restoration from the evidence at hand. The ilium as preserved measures 46.5 mm. long by 264 mm. high.

The pubes show the characteristic plate-like expansion in their mid-length seen in *Y. colurus* but their outline as preserved is too vague for further description.

The ischia are well preserved except that their proximal end is buried in the matrix and their distal end destroyed. They curve downward and inward as in *polyzelus*.

The femur is well developed, very similar to that of *colurus* in outline and in the relative extent of the fourth trochanter. The bone is extremely thin-walled, that of the right being but 1.5 mm. in thickness in mid-shaft. The measurable length of the femur is 102 mm. which is probably somewhat less than its original dimension; Huene makes it 120-150 mm. The tibia according to Marsh measures 88 mm. The fibula of the right limb is exposed on the other side of the block, and lies some little distance away from, though parallel with the right tibia. This emphasizes Marsh's statement that in *Anchisaurus* the fibula is bowed outward from the tibia. This together with the breadth of the ankle would give a somewhat clumsy lower leg as a characteristic of his genus. The foot in so far as it is known resembles essentially that of *Y. colurus*, but the third metatarsal is only half as long as that of *Y. colurus*, which may be taken as indicating the comparative size of the feet in the two species.

My personal estimate of the length of *colurus* is about seven feet while *solus* was approximately half that size. The only footprint which I can correlate with this dinosaur is *Grallator tenuis*, a discussion of which will follow in the succeeding section (p. 154).

Infraorder Cœlurosauria
Family AMMOSAURIDÆ
Genus *Ammosaurus* Marsh

Anchisaurus (in part)

Marsh, O. C. 1891, Amer. Jour. Sci., (3) xlii, p. 267.

This genus, which includes but one known species, *A. major*, was erected by Marsh subsequent to the specific description, when more material referable to *Yaleosaurus* gave characters at variance with those of *major*. Marsh's discussion of the new genus is as follows:

"The Yale Museum has recently secured two interesting specimens of Dinosaurs from the Triassic sandstone of the Connecticut valley. In comparing these with the known species of *Anchisaurus* from this formation, the fact became evident that among them are two well-marked genera. One of the two specimens, which is described below [*Y. (A.) colurus*], cannot now be distinguished generically from the type of *Anchisaurus*, while the one described by the writer as *Anchisaurus major* is quite distinct, and hence a new genus is here established for its reception. The distinctive characters are well marked in the pelvic arch.

"There are three vertebræ in the sacrum, but they are not co-ossified with each other, being free, as in the Crocodilia. The ilium is comparatively small, and has a slender pre-acetabular process. The pubes are broad, elongate plates, perforate above, and not co-ossified with each other. In form, they resemble the corresponding bones in *Zanclodon*, where, however, the two are co-ossified, and imperforate. The ischia meet the pubes by an extensive union. Their distal ends are slender, directed backward, and closely adapted to each other. This species may now be known as *Ammosaurus major*."

Ammosaurus major Marsh

Marsh, O. C. 1889, Amer. Jour. Sci., (3) xxxvii, p. 331, fig. 1 (*Anchisaurus*).

Marsh, O. C. 1891, *Ibid*, xlii, p. 267.

Huene, F. v. 1906, Din. Aussereurop. Trias, pp. 15-19, pls. v-ix, fig. 1.

Huene, F. v. 1908, Din. Europäischen Trias, Lief. 5, p. 303.

Huene, F. v. 1932, Mon. Geol. u. Pal. Ser. 1. Heft 4, p. 26.

Holotype: Cat. No. 208, Y. P. M.

Locality.—Manchester, Conn., quarry of Charles O. Wolcott; with *Yaleosaurus colurus* and *Anchisaurus solus*.

Horizon.—Same as that of *Yaleosaurus colurus*.

Original Description.—"The remains of this reptile are from the sandstone of the Connecticut River valley, which has long been known for the great variety of footprints it contains, especially those supposed to have been made by birds. The extreme rarity of any bones in these beds is equally well known, not more than half a dozen finds having yet been made, and only a few of these of much scientific interest. A portion of a skeleton found near Springfield, Mass., and described by Hitchcock, in 1865, as *Megadactylus*, has hitherto been by far the most important of these discoveries. It is a typical member of the order *Theropoda*, and has apparently for its nearest allies in the old world, *Thecodontosaurus*, from the Trias of England, and *Massospondylus*, from the same formation in South Africa.

"The remains here described represent a later discovery, in 1884, near Manchester, Conn., in essentially the same horizon as the Springfield specimen. They indicate an animal of larger size, but in many respects nearly allied to the one described by Hitchcock. Both apparently belong to the same genus, which the writer has called *Anchisaurus*, as the name first given was preoccupied.

"The present specimen is part of a skeleton which was probably complete, and in position, when discovered, but for want of proper appreciation at the time, only the posterior portion was secured. This consists of the nearly entire pelvic arch, with both hind limbs es-

entially complete, and in position. As this was one of the animals that are supposed to have made the footprints, one of the hind feet is figured below [fig. 20].

"In the present specimen there are only three sacral vertebræ. All the dorsal vertebræ preserved have their articular ends biconcave, or nearly plane.

"The ilium has a slender preacetabular process, thus differing from most of the other *Theropoda*. The ischia are very slender, and are directed backward. For the posterior half of their length, they are closely adapted to each other.

"The known remains of this species indicate an animal about six or eight feet in length."

The unfortunate loss of the anterior portion of this skeleton, which was built into the abutments of a bridge before the full value was realized, has already been described (*vide supra* p. 61). Professor Marsh tried in vain to locate the block containing the specimen, but when it became evident that little short of the total destruction of the abutments might be necessary, the search was given up and the bridge still has the unique distinction of being the mausoleum of a dinosaur.

The portion collected includes the entire pelvic and sacral region together with the nearly complete hind limbs, practically articulated, and indicating that the animal died or at least was entombed in a peculiar squatting posture as though forcibly pressed downward from above. The bones are in good condition, parts of them wonderfully preserved, though there is some evidence of crushing, notably in the left femur and tibia. The resistant character of the coarse red sandstone renders inadvisable the entire freeing of the bones as is usual with material from this horizon.

Of the vertebral column six bones are present of which three constitute the sacrum while the remaining three are presacral. The presacral vertebræ are embedded in the matrix on their ventral side, so that little of the character of the centra can be seen. The neural spines are rectangular in shape, low and long, that of the penultimate vertebra being 37 mm. in length by 18 mm. high. The zygapophyses are well developed, their facets lying parallel with the longitudinal axis of the vertebra in its lateral aspect, but looking sharply inward on the part of the anterior zygapophyses and outward in the posterior ones.

The dorsal ribs preserved are relatively stronger than in *Yaleosaurus*, that of the penultimate vertebra being distinctly flattened, partly, I imagine, due to crushing. The tuberculum articulates with the extremity of the transverse process so that the upper surface of the two bones appears essentially continuous.

The combined length of the posterior three of the presacrals measured over the zygapophyses is about 165 mm.

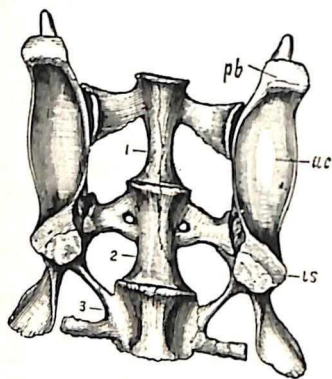


FIGURE 19.

Ammosaurus major Marsh.
Pelvis, ventral view. One-fourth
natural size. After Marsh.
a, acetabulum; is, ischial peduncle;
pb, pubic peduncle; 1, 2, 3, sacral
vertebrae.

ilium not far from the pubic peduncle, though its present point of contact is below that which it must have had during life. The second sacral rib has a broader origin covering in this instance more than half of the length of the centrum though still attached to the anterior moiety of the latter. Ventrally it shows a pit-like depression at its proximal end so as to appear practically two-headed, while distally it tapers in a reverse manner to that of the first rib, and its point of contact with the ilium lies nearly opposite the ischial peduncle, so that the two anterior sacral ribs tend thus to reinforce the acetabulum and receive the thrust of the thigh. The sacral rib of the third vertebra is very peculiar; arising as it does from the *posterior* two-thirds of the laterally extended centrum it bifurcates widely, one limb passing outward and forward at an angle of 45° with the long axis of the insertion of the second rib. The posterior limb on the contrary runs upward and outward perpendicular to the axis of the centrum and meets the posterior portion of the blade of the ilium itself (see fig. 19). The dorsal spines of the sacrum are relatively higher than those of the presacral vertebrae and slant obliquely backward.

The length of the first centrum is 52 mm., of the second 48.5 mm., and of the third 37 mm. The length of the anterior sacral rib is 30 mm., its distal antero-posterior diameter 31 mm.; the same measurements of the second are 34 mm. and about 12 mm. respectively, while the anterior limb of the third measures 30 mm. and its posterior limb 37 mm. The only form known to me (or Huene) in which the last sacral rib is of this character is the sauropod *Brontosaurus excelsus* of the American Morrison. Marsh in his restoration of *Yaleosaurus* shows the posterior sacral rib to be of this type. As this element is

The sacra, the ventral aspect of which is displayed as well as that of the dorsal side, are, as Marsh has said, uncoössified so that, while closely applied to each other, a slight lateral and downward displacement has occurred between each two of the series. The centra are of solid construction, the anterior two being constricted medially like the dorsals of *Yaleosaurus*, while the posterior one which is much shorter than its predecessors is broadened out into a peculiar form. In a like manner the sacral ribs, visible only from below, present peculiarities. The anterior rib arises from the extreme forward portion of its centrum and covers about one-third of the latter's length. Distally it broadens out and abuts against the

unknown in the *Yaleosaurus* specimen, it must have been restored from *Ammosaurus* and is a possible source of error so far as the restoration of *Yaleosaurus* is concerned. Its correctness or incorrectness, however, cannot now be proved.

Appendicular Skeleton.—Pelvic Arch. The right ilium is practically intact, while the posterior half of the left is destroyed. This bone is peculiar, as Marsh has said, in the very slender anterior process which arises at a sharp angle from the long, slightly curved pubic peduncle, similar to that of *Anchisaurus solus*, except that the angle is more acute, doubtless due in part to crushing in the present instance. Indeed the shape of the ilium resembles that of the type of the sauropod *Morosaurus lentus*, Cat. No. 1910, Y. P. M., more than it does that of the carnivorous *Creosaurus atrox*, Cat. No. 1890, Yale Museum, except that in *Morosaurus* the anterior process is broader and sharply twisted on its long axis, so that, presenting as it does an edge view when observed from the side, it heightens the apparent similarity between this ilium and that of *Ammosaurus*. What the significance of this is, taken in conjunction with the peculiar third sacral rib which so resembles that of *Brontosaurus excelsus*, I cannot say, but they seem to be what Osborn has called *homogenetic* characters, potentially derived from a common ancestor.

Posteriorly the blade of the ilium broadens so that its greatest depth is just anterior to the ischial peduncle. Posteriorly the blade seems to have terminated in an acute angle but there is no angle of demarcation between the posterior process and ischial peduncle. The length of the ilium was about 200 mm., its greatest height 81.5 mm., length of the anterior process 52 mm., and the antero-posterior diameter of the acetabulum 73 mm.

The pubes are broadened at their proximal end so as to meet at once in symphysis in the mid-line of the body. There seems to have been a large oval obturator foramen clearly outlined in the left pubis, more obscurely in the right one, behind which lies the roughened margin for articulation with the ischium. In *Yaleosaurus*, it will be remembered, there is a hook-like process at the proximal end of the pubis, but the obturator foramen which is doubtless homologous with the area within the curve of the hook is not otherwise present.

Anteriorly the pubes of *Ammosaurus* continue, so far as they are preserved, in a flattened, blade-like shaft curved slightly in the vertical plane so as to be convex when viewed from below. The shaft of the right and that of the left pubis seem to have been in contact along their entire inner margin. The preserved length of the left pubis is 175 mm., its proximal width 85 mm., the greatest (transverse) diameter of the obturator foramen 48 mm.

The ischia differ from those of *Yaleosaurus* in that they, like the pubes, are flattened, plate-like bones in their proximal portion though evidently thickening in the shaft which is preserved apparently for about half its length. The ischia seem to approach each other more

anteriorly than in *Yaleosaurus*. Much of their true character, however, is obscured by the matrix. The preserved length of the left ischium is 144 mm. and its proximal breadth 79 mm.

The femora are both somewhat damaged, so that in neither case is the entire length preserved, the distal end being lacking in each instance. In general form, so far as a comparison may be made, the femur of *Ammosaurus* resembles that of *Yaleosaurus* except that the fourth trochanter does not seem to be quite so prominent. The head has a broad surface for the articular cartilage attachment, the bone at this point being again suggestive of the Sauropoda. There is, however, a reversed curvature as in *Yaleosaurus*, though much less pronounced. Some of the loss of curvature may be due to crushing, as the femur lies in the plane of sedimentation. The preserved length of the right femur, actual bone and matrix impression, is 266 mm., breadth of proximal end 53 mm., and distance of fourth trochanter from proximal end 130 mm. The trochanter is, therefore, relatively low on the shaft compared with *Yaleosaurus*.

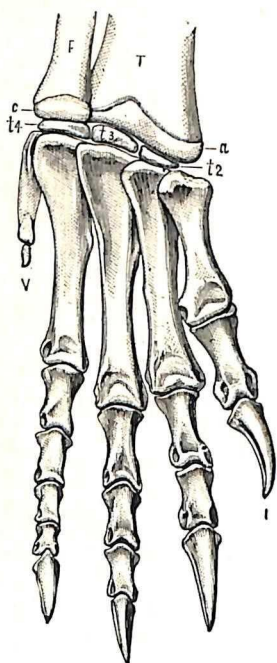


FIGURE 20.
Ammosaurus major Marsh.
Right hind-foot. One-fourth
natural size. After Marsh.
a, astragalus; c, calcaneum; f,
fibula; t₁-t₄, tarsalia; t, tibia;
f, digit one (hallux); v, digit five.

The tibiae are also in poor condition, and only the proximal end of one fibula (right) remains. Proximally the tibia resembles that of *Yaleosaurus colurus*, with a well developed cnemial crest. Externally it is flattened so that a distinct angle is formed between the outer and posterior aspects of the bone. Whether the fibula was bowed outward as in *Yaleosaurus* is difficult to decide; certainly the axes of the proximal end of the two bones as preserved do not lie parallel to each other. Of the right tibia nearly the entire length is preserved, the distal end being somewhat broken, while of the left the reverse is true though the preserved bone is in this instance much the shorter of the two.

Length of right tibia as preserved 246 mm., antero-posterior diameter of proximal end 54 mm., width of shaft 100 mm., distance from proximal end 18 mm. Present antero-posterior diameter of crushed proximal end of right fibula, 30 mm.

The right foot has been figured by Marsh (fig. 20) with accuracy, except that during life the hallux was possibly rotated to the rear as the correlated footprints (*Anchisauripus*

exsertus) seem to imply. The ungual of that digit is also sharply curved in the left foot, though straightened somewhat by pressure in the right, far too much curved for an ambulatory ungual. That the entire foot was a powerful grasping organ is forcibly shown by the present clenched attitude of the right foot due to post-mortem contraction of the flexor muscles of the leg.

The low astragalus without ascending process typical of the Anchi-sauridæ, is preserved together with the calcaneum, and what Marsh has identified as tarsalia 2, 3, and 4 of the second row, which Huene (1906, p. 18) calls after analogy with other forms the cuneiform II and III and the cuboid. The metatarsalia Huene says are not dissimilar to those of the Plateosauridæ.

Length of metatarsal I, 73.5 mm.; of II, 114.5 mm.; of III, 135 mm.; of IV, 130 mm.; of V, 61 mm. Length of first phalanx of digit I, 46 mm.; of the ungual, 48 mm.; of digit II, first phalanx, 44 mm., second 31.5 mm., ungual, 51 mm.; of digit III, first, 45 mm., second, 37.4 mm., third, 30 mm., ungual, 35.7 mm.; of digit IV, first, 39.5 mm., second, 29 mm., third, 23 mm., fourth, 19.5 mm., ungual, 44 mm.

If the relative proportion of parts of *Ammosaurus major* were approximately that found in *Yaleosaurus colurus*, the length of the former would be 8 feet 9 inches or 2.6 m. if that of the latter was 7 feet. *Ammosaurus major*, however, seems to have been somewhat the more robust of the two.

Family PODOKESAURIDÆ

Vertebrae and limb bones hollow. Pubes long and slender, ischia shorter. Femur shorter than tibia. Metatarsals long; manus and pes with three functional digits.

To this group of slender limbed, agile dinosaurs belong *Compsognathus* of the Solenhofen lithographic limestone (Middle Jurassic) and also apparently *Ornitholestes* from the Morrison (Upper Jurassic or Lower Cretaceous of Wyoming) and *Ornithomimus* of the Upper Cretaceous of Wyoming, Montana and Alberta. To these must now apparently be added a form which antedates all the others in geologic time and which may prove to be ancestral to some at least of the later American genera. *Podokesaurus* is the latest accession to the growing list of osseous fossils of the Connecticut valley, and was found by Doctor Mignon Talbot, then Professor of Geology in Mount Holyoke College, in 1911. Years before the discovery of *Podokesaurus* the presence of dinosaurs of this character in the Newark rocks was suspected by the writer (Lull 1904A, p. 544) who says in speaking of the ichnite genus *Grallator*:

"Another abundant genus is *Grallator*, characterized by very long limbs and small, compact feet without an impressing hallux and with no tail trace. The proportions of length of limbs to those of feet are the same as in the bustards, and the forms which made the tracks were



PLATE VIII.—The coelurosaurian dinosaur *Podokesaurus holyokensis* Talbot. From a lantern slide of the type specimen which was destroyed by fire at the Mt. Holyoke College Museum. About one-fourth natural size.

probably aberrant carnivores of habits somewhat similar to those of wading birds, possibly feeding upon feebler reptiles and amphibians, or on fish. In considering the probable relationship of this genus to genera known from their skeletal remains one is reminded strongly of *Ornithomimus*, a Cretaceous compsognathoid dinosaur."

Genus *Podokesaurus* Talbot

Podokesaurus holyokensis Talbot

Talbot, M. 1911, Amer. Jour. Sci., (4) xxxi, pp. 469-479, pl. iv, text figs. 1-6.

Huene, F. v. 1932, Mon. Geol. u. Pal., Ser. 1. Heft 4, p. 35. pl. 49, fig. 2.

Type specimen preserved in the museum of Mount Holyoke College, South Hadley, Mass., until lost by fire.

Locality.—In a glacially carried boulder, not far from the site of Mount Holyoke College. The parent ledge must lie on the south side of the Holyoke range not more than two or three miles north of the place where the specimen was found.

Horizon.—Longmeadow sandstone in the "upper [Portland] series of sandstones, shales and local conglomerates"; a contemporary of *Stegomosuchus longipes* and probably of *Anchisaurus*, *Ammosaurus* and *Yaleosaurus*.

Miss Talbot's original description follows:

"In a boulder of Triassic sandstone which the glacier carried two or three miles, possibly, and deposited not far from the site of Mount Holyoke College, the writer recently found an excellently preserved skeleton of a small dinosaur the length of whose body is about 18 cm. The boulder was split along the plane in which the fossil lies and part of the bones are in one half and part in the other. These bones are hollow and the whole framework is very light and delicate.

"As the fossil lies in the rock, most of the bones are in position, or nearly so, with the exception of the skull and tail. A detached tail that probably belongs to this specimen lies a few centimeters from the rest of the skeleton, and near it are three very thin bones that may belong to the skull (fig. 3, A, B, and C; Pl. iv, fig. 3) [fig. 21 and pl. viii]. Two of these bones are bilaterally symmetrical and one of them is broadly convex with a well-defined median sulcus. They are all more or less embedded in the rock and cannot be described until the rock is removed. The other bones are better exposed and will be described below.

"In the description which follows these features are to be noted: Light construction—hollow bones; slender, straight femur; position of fourth trochanter; position of fibula, lying close to the tibia; great length of tibia and metatarsals; small humerus; narrow shaft of ischium; great length of pubis; length of vertebræ.

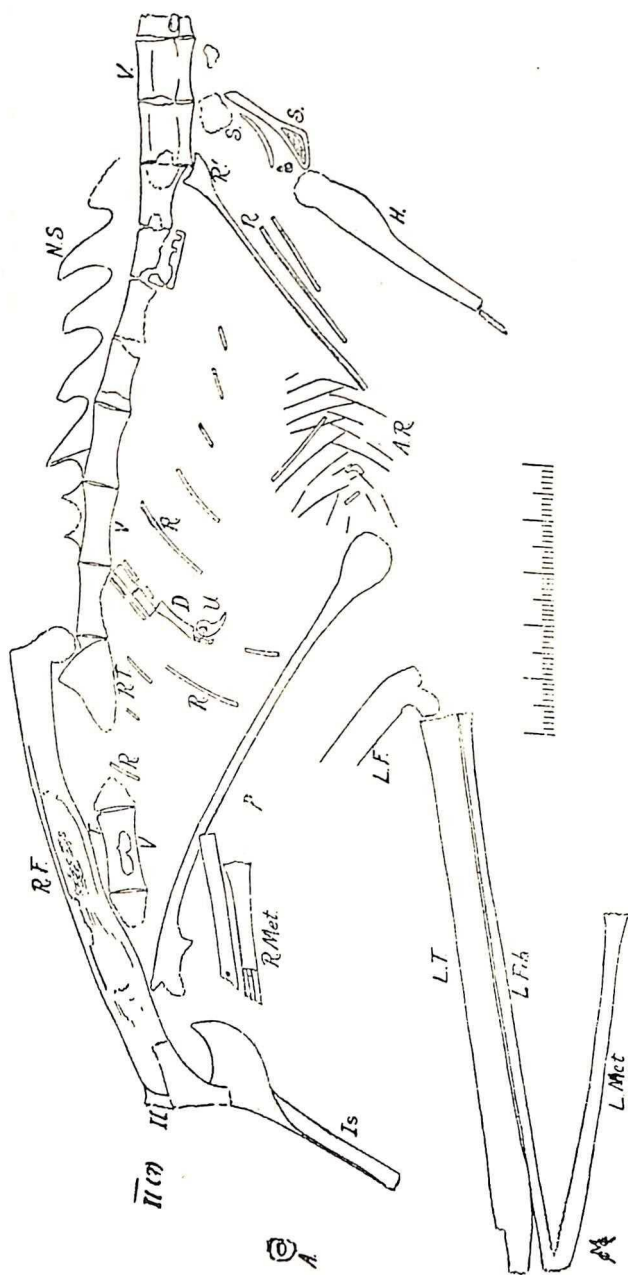


FIGURE 21.

Podokesaurus holyokensis Talbot. Skeleton, right side, two-thirds natural size. After Talbot. A, astragalus; AR, ventral ribs; D, manus; H, humerus; IS, ischium; LF, left femur; L.Fib, left fibula; L.Met, left metatarsals; LT, left tibia; NS, neural spines; P, pubis; R, ribs; R', proximal end of ribs; RF, right femur; R.Met, right metatarsals; RT, right tibia; S, coracoid and scapula; T, fourth trochanter; U, ungual; V, vertebrae.

"Fore Limb.—The humerus (fig. 1, H) [fig. 21] is a very delicately shaped bone, 42 mm. long (not quite half the length of the femur), slender and well rounded, with high radial crest. The proximal end shows a slight constriction above the crest, and below the bone tapers gradually to a diameter of 3 mm. at the distal end. Measured through the crest it is 8 mm. There is a trace of the impression of the radius or ulna just beyond the distal end.

"In the scapular region is a broad, flat bone, lying vertically in the rock, but twisted on its long axis at a right angle, midway of its length (fig. 1, S) [fig. 21]. This bone has a length, as shown, of 20 mm. and a width of at least 3 mm. Lying near its proximal end is another flat bone, 8 mm. long by 5 mm. wide. These may be three separate bones, more or less firmly united in the living animal. Further development is necessary, however, to bring out their outlines and their relation to each other.

"Hind Limb.—The femur (fig. 1, R. F. and L. F) [fig. 21] is slender and nearly straight with thin walls. The bone is expanded on the back side at the distal end. The length is 86 mm., and the diameter, just distalwards from the fourth trochanter, is 6.5 mm. The fourth trochanter (fig. 1, T.) [fig. 21] is 18 mm. long and about 2 mm. high and is situated just beyond the middle of the shaft, toward the distal end.

"Only the proximal end of the right tibia (fig. 1, R. T.) [fig. 21] is exposed and there the bone is well rounded. This, however, may be only a small part of the proximal end, as the bone is embedded in the rock. The left tibia (fig. 1, L. T.) [fig. 21] is split lengthwise, part of the bone lying in each half of the boulder. It is an almost straight, narrow shaft with the surface lying uppermost bent slightly at the proximal end, due, probably, to the expansion of the bone. In the position in which it lies, the bone is of nearly the same diameter throughout, about 7 mm. Its length is 104 mm. Lying close against the tibia and of almost equal length is the extremely thin fibula (fig. 1, L. Fib. [fig. 21].

"There is a small, convex bone, 4 mm. by 6 mm., lying where the right tibia and metatarsals should meet, that may be the astragalus (fig. 1, A.) [fig. 21]. It shows no sign of an ascending process.

"Two of the right metatarsals (fig. 1, R. Met.) [fig. 21] lie in position. Their diameter is 2.5 mm. and 3.5 mm., respectively, along the shaft, but at the distal end there is an expansion to a diameter of 5 mm. In position, at the distal end of the left tibia there is one metatarsal (fig. 1, L. Met.) [fig. 21] slightly curved and 65 mm. long. Alongside are traces of a second. One of the digits (fig. 1, D.) [fig. 21], whose divisions are indistinctly shown, lies between two ribs not far from the right metatarsals. It is 20 mm. long and 1.5 mm. in diameter and is terminated by an ungual 7 mm. long. Cross sections of two bones near this one look like unguals.

"Pelvis.—The pelvic bones are partly covered by the right femur

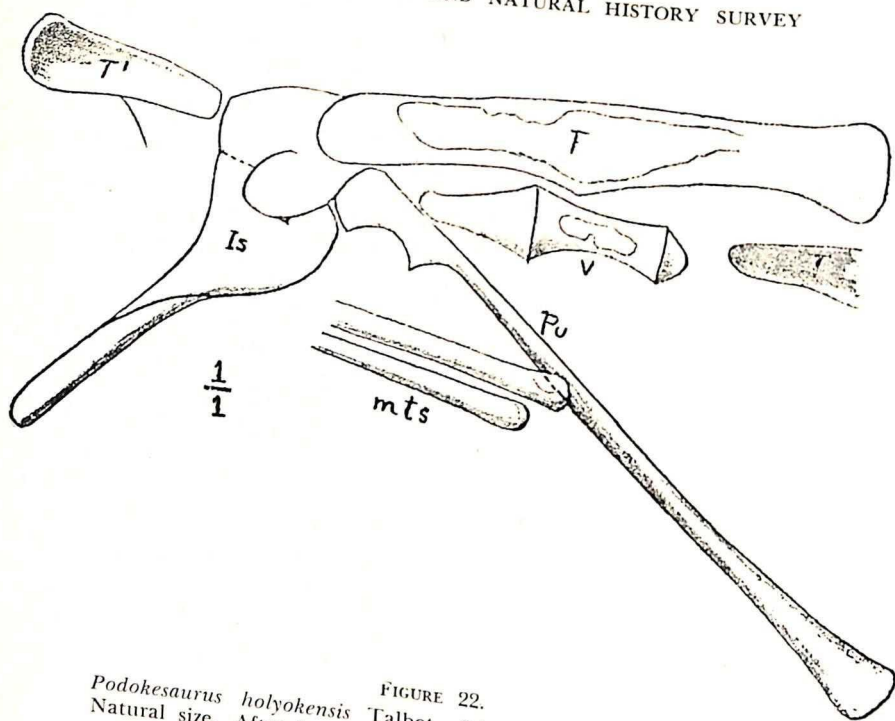


FIGURE 22.
Podokesaurus holyokensis Talbot. Right view of pelvic region.
 Natural size. After Lull. F, femur; Is, ischium; Mts, metatarsals;
 Pu, pubis; T, T', tibia; V, vertebra.

and their outline is not distinct. What is probably the pubis (fig. 1, P., and fig. 2, Pu.) [figs. 21, P and 22, Pu], is a remarkably long thin bone, 95 mm. long, expanded at the distal end. The bone seems to be in position and makes an angle of about 40° with the line of the vertebral column. Its length is comparable with that of a new, undescribed form from northern Württemberg.

"The ischium (Pl. iv. fig. 2 [Pl. viii]; fig. 1 and fig. 2, Is. [figs. 21, and 22]) is well rounded, anteriorly, and has a shaft 4 mm. wide of which a length of 30 mm. is exposed.¹ The distal end is embedded in the rock. The contact with the ilium and the acetabular edge is obscurely visible.

"There is a bone running posteriorly from the head of the right femur which may be the posterior process of the ilium (fig. 1 and fig. 2, Il.) [*vide infra* p. 140], the anterior process being covered by the femur. This posterior extension can be traced indistinctly for 27 mm. and either points upward or continues the line of the posterior part of the vertebral column.

"*Vertebrae*.—Of the *vertebrae* there are visible seventeen presacral (fig. 1, V.) [fig. 21] and thirteen caudal (fig. 3, V.) [fig. 24], all very

¹ The illustrations seem to indicate the presence of two bones, but this may be due to the presence of a ridge on the ischium, as is seen in *Compsognathus*.

light and hollow, and some, at least, slightly concave at each end. The presacral vertebræ are slender, the measurements for the sixth presacral being 4 mm. through the middle of the centrum, 6 mm. at the ends and 15 mm. from end to end. A strong, gracefully curved neural spine (fig. 1, N. S.) [fig. 24] arises from the vertebræ in the dorsal region, about 10 mm. high and 12 mm. long at the base. The first two or three presacrals are a little larger than the others, and those at the anterior end of the column, much stronger. One of the latter measures 10 mm. at the end and the diameter through the middle of the centrum is only a little less. They are not so long, however, measuring only 12 mm. to 13 mm. One of these vertebræ is shown in cross section at a thin edge of the rock and has a transverse diameter through the cavity of the centrum of 4 mm. while the height of the cavity is 5.5 mm. (fig. 4) [fig. 23].

"The caudal vertebræ are only a little expanded at the ends and are very slender throughout their length. A typical one is 17 mm. long with a diameter of 4 mm. at the ends. The neural spines, if such they are (fig. 3, D.-G.) [fig. 24], are of different shapes. These caudal vertebræ are so nearly of a size, one with another, that there is no apparent tapering of the series and it is not clear which is the proximal end of the tail, nor is it possible, as yet, to estimate its length [*vide infra*].

"*Ribs*.—Quite a number of ribs (fig. 1, R.) are visible, all very slender and hollow, but the proximal end is not exposed save in one instance where the bone is so broken that the outline is not distinct. Near this proximal end, however, the bone is somewhat concave and expanded as if it might be bifurcate (fig. 1, R.) [fig. 21]. The largest rib uncovered is 52 mm. long and 2 mm. wide toward the proximal end, while in no place does the thickness seem to be more than 1 mm. The most anterior of the cervical vertebræ preserved have long ribs. These are on another piece of the boulder and are not figured.

"Just anterior to the distal end of the pubis there is a small cluster of gently curved abdominal ribs (fig. 1, A. R.) [fig. 21], exceedingly slender and dove-tailed as they lie in the rock, the position due, probably, to slipping. This mass of interlacing ribs covers a space of 40 mm. by 23 mm. There are at least eleven of these ribs on each side of the median line, the largest of which is 18 mm. long and so small in diameter that the bone looks like a mere thread in the rock. Slender as are these ribs, they seem to be hollow.

"*Sternal Element* (?).—In the center of this mass of abdominal ribs is a small body that responds to dilute hydrochloric acid, as do all of the bones. The part exposed measures 5 mm. by 3 mm. This may be one of the sternal elements displaced.

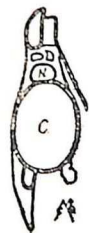


FIGURE 23.
Podokesaurus
holyokensis
Talbot. Cross-section
of vertebræ.
Twice natural size.
After Talbot. C,
centrum; N, neural
canal.

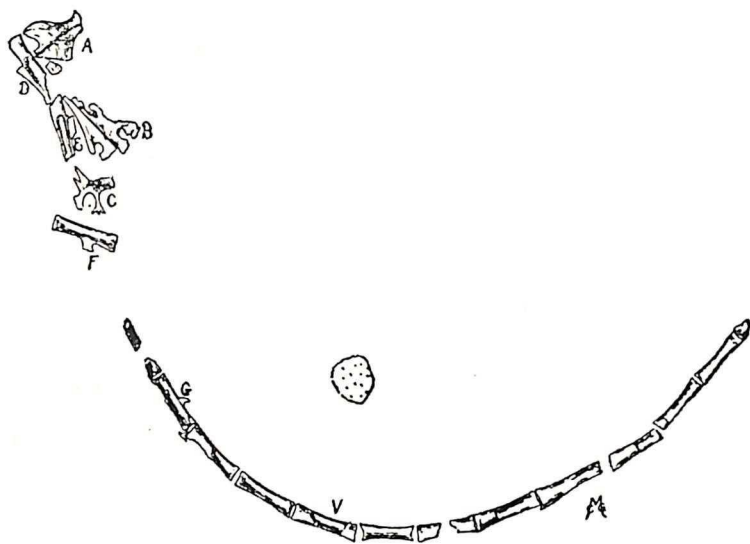


FIGURE 24.

Podokesaurus holyokensis Talbot. Caudal vertebrae and skull bones (?). A, B, C, possible skull bones; D, F, V, vertebrae; G, neural spine.

"*Gastrolith*.—Lying 10 mm. away and still among these ribs, is a small piece of quartz, a flat, well-rounded pebble, 1 mm. thick and 10 mm. long. The width exposed is 4 mm., but more of the pebble is embedded in the rock. There are no other pieces of quartz larger than a grain of sand visible in the boulder, and considering this fact, considering, also, its smooth, polished surface and its position, the writer concludes that this must be a gastrolith. This would seemingly be the first record of gastroliths found with carnivorous dinosaurian remains."

Doctor Talbot goes on to a comparative discussion of the points of *Podokesaurus* as contrasted with various orthopod and theropod dinosaurs. So far as classification is concerned, she interprets the fossil under discussion as a carnivorous dinosaur "because of the length, shape, and position of the pubis and the absence of a postpubis," and upon these positive and negative characters she rests her case.

Further Description.—Through the courtesy of the authorities of Mount Holyoke College the type specimen of *Podokesaurus* was loaned to the Yale Museum for further study and was placed in the skilful hands of the head preparator, Hugh Gibb, for development. The result of his labors, however, brought to light little that was new. It did serve to correct some earlier notions of interpretations, most of which Miss Talbot was able to avail herself of before the publication of her description.

The elements lying a little distance behind the body, which were supposed to be bones of the skull, proved to be mere flakes of bone which subsequent development did not serve to amplify. One of the

bones which the author speaks of as "bilaterally symmetrical . . . broadly convex with a median sulcus" may indeed be cranial as it is not identifiable as anything else. If so it is doubtless from the dorsal wall of the skull, the median sulcus representing the mid-line, which would place the element not far from the paired frontal bones of the cranium. The vague outlines were rendered no more distinct by further preparation (see fig. 24, A). Of the remaining bones, those at B and C may also be cranial as Miss Talbot has said; if so two of them (fig. 24, B) are apparently paired elements from the mid-line of the skull and as such can only be identified as nasals. An apparently symmetrically placed aperture through the broader posterior? portion of each bone is unknown in this element. The bone, however, is so thin a vestige of osseous material that accidental apertures are likely to occur where the bone is naturally thinner. For the odd bone C, I cannot suggest a location.

Vertebral Column.—The number of presacrals preserved is fifteen and a half (two and a half being in another block) of which I should call twelve dorsals and the remainder cervicals. There is, however, at least one more dorsal, possibly two, before the sacral series is reached, to be accounted for, making possibly fourteen dorsals and perhaps eleven cervicals including the atlas, giving in all at least twenty-four in the presacral series, compared with twenty-six in *Compsognathus* (Marsh's restoration) and twenty-eight in Osborn's estimate for *Ornitholestes*.

It is my impression that the "detached tail" of *Podokesaurus* really lies in its proper position with reference to the remainder of the skeleton and has not been pulled away, but merely that the missing vertebræ have been swept away, for in the neighborhood of the cranial elements already discussed there lie at least three detached caudals though probably not very far removed from their relative position. Scattered through the matrix and still more or less in the line of the tail lay other splinter-like bone fragments which may represent other débris of the tail. Miss Talbot remarks upon the uniformity of size of the articulated series of caudal vertebræ which makes it difficult to distinguish the proximal from the distal end. This is no longer true, however, for further development laid bare twelve more bones in the series, completing the tail distally. This would seem to imply a tail of great length which, because of its extreme lightness would be necessary to serve as an adequate counterpoise to the forward part of the body, on the principle that an ounce weight at the end of a 17-inch lever would be as efficient as a pound at a distance of one inch from the fulcrum. I have therefore restored no fewer than forty-six caudal vertebræ, as compared with forty-four in *Ornitholestes* (Osborn) and thirty-seven in *Compsognathus* (Marsh). If this estimate be true, the preserved series of caudals are numbers 18-46, the scattered ones being all proximal to the continuous series.

The cervical vertebræ preserved are relatively large both in length and diameter as compared with the dorsals. Their neural spines are either not preserved or were extremely low, and the vertebræ were

provided with the styliform cervical ribs characteristic of *Compsognathus*, none of those of *Ornitholestes* being preserved (I judge from the shading in Osborn's picture, Osborn 1903, fig. 1). The length of the centrum of the second preserved cervical (estimated ninth of the series) is about 21 mm.

The anterior dorsals are much shorter, after which the vertebræ again increase in length toward the pelvis.

The neural spines are high but not so extended antero-posteriorly as in *Compsognathus*, those of *Ornitholestes* being apparently imperfect. The transverse processes form the arc of a circle downward on either side extending about as far from the centrum as the spinous process is high. The zygapophyses are well developed but ill preserved as the bony matter is largely dissolved away. Relatively the centra of *Podokesaurus* are much longer than in *Ornithomimus*; on the other hand those of *Compsognathus* while still shorter than in *Podokesaurus* resemble them more nearly.

No sacral vertebræ are visible upon the specimen.

The caudals preserved are extremely long and slender, and together with the preserved chevrons, resemble those of *Ornitholestes* quite closely. They are interesting in showing no diminution in length until the last few of the entire series are reached.

The proportions of the vertebral column as restored, measured on the curve, are; neck 130 mm., back 170 mm., sacrum 45 mm., and tail 730 mm., giving an estimated length of 1150 mm. (3 ft. 9 in.) for the entire animal including the head, as compared with 2220 mm. (7 ft. 3 in.) for *Ornitholestes* and 608 mm. (2 ft.) (Marsh's figure) for *Compsognathus*.

The ribs and abdominal ribs have been sufficiently described by Miss Talbot.

Appendicular Skeleton.—The bone interpreted by Miss Talbot as a scapula seems to be in part at least the coracoid. This element, lying perpendicular to the plane of fracture of the rock, shows its cancellous inner texture within the thickened portion near the synarthrosis and glenoid fossa. The preserved part of the coracoid is 13 mm. high by 9 mm. in antero-posterior section. The remainder of the bone lying in the plane of fracture of the rock may represent the scapula but is indefinitely obscure in outline.

The humerus is quite similar to that of *Ornitholestes* except that as preserved the radial crest is not so high. It gives by no means the sense of muscular power shown in that of *Anchisaurus solus*, which was doubtless a much more aggressive animal though showing far less cursorial adaptation than *Podokesaurus*. The manus of *Podokesaurus* is more *Compsognathus*-like than *Ornitholestes*-like, but the latter is a rare specialization.

The pelvis is highly characteristic, particularly in the pubic bones,

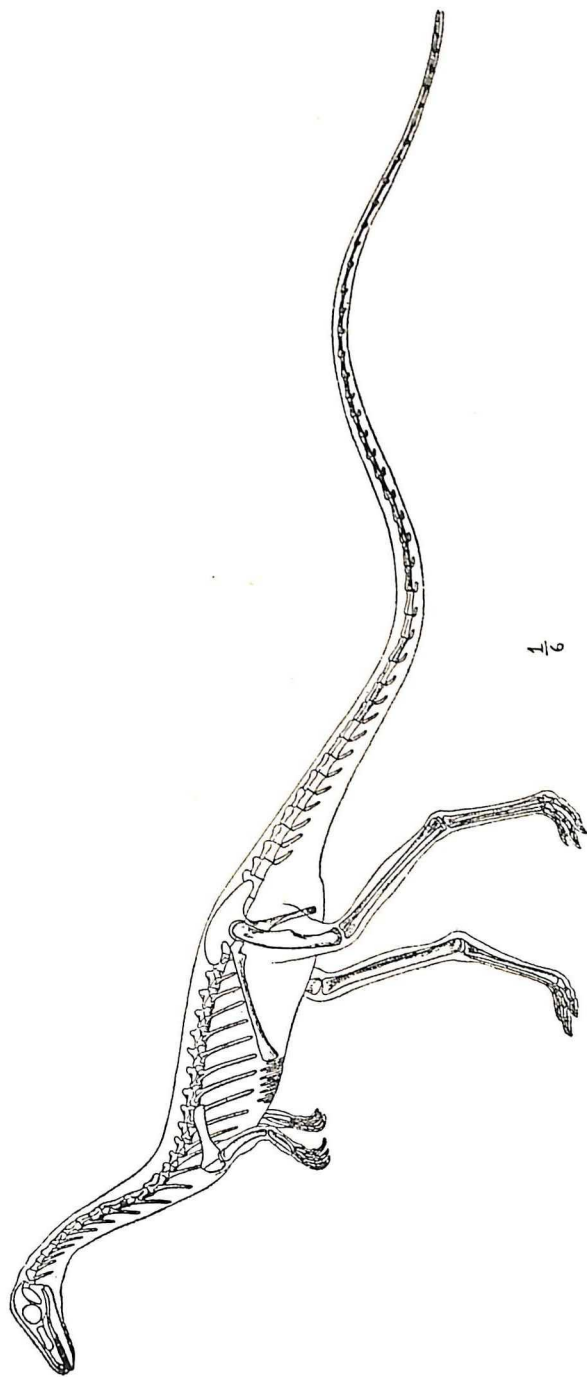
 $\frac{1}{6}$

FIGURE 25.

Podothesaurus holycensis Talbot. Restoration. One-sixth natural size. After Lull. The shaded elements are present in the fossil, the other portions being restored after *Compsognathus*.

which resemble, as Doctor Talbot has said, those of a dinosaur from Württemberg, described by Fraas.¹

There is no trace of the ilium. That which the describer considered a trace of the posterior portion proves to be part of the right tibia, broken in such a way that the extremely thin wall outcropped in a slender line.

The pubis lies approximately in position², an extremely long bone expanding both at distal and proximal end. Seen edgewise as it outcropped from the matrix the shaft of the bone seemed excessively thin, but further preparation of the specimen showed a width of at least 6 mm. in mid-length, and it may well be more, so that it shows something of the plate-like expansion of *Ammosaurus*, though with a process delimiting the proximal extent of the obturator notch as in *Yaleosaurus colurus* rather than a distinct obturator foramen.

The entire length of the pubis is 95 mm. while the distal expansion measures 10 mm. in diameter. In *Ornitholestes* the distal end of the pubis unfortunately is not preserved so that its length appears conjectural. It has apparently, however, neither the angulation with the vertebral column nor the straight flattened shaft seen in *Podokesaurus*.

The ischium is essentially as described by Miss Talbot but has now been developed for its entire length. It measures 55 mm. long and 15.5 mm. wide at the proximal end while the shaft measures 4 mm. in diameter. This bone is more like that of *Compsognathus* than of *Ornitholestes* but does not show any very marked distinctions from either.

The femur, tibia and fibula are as described; further development however has exposed the metatarsals of the right leg, and they are so closely appressed together as to form a wonderfully compact structure, perhaps even more so than Marsh has described for *Ornithomimus* (1896 B, p. 204, pl. lviii, fig. 2 A). There is apparently even here no actual fusion into a cannon bone, which still remains a distinctive feature between dinosaurs and birds.

The metatarsals exposed are three in number with no trace of the first. It may have been present, however, though the digit was never even subfunctional if one may judge again from the correlated footprints. The length of the metatarsals is 75 mm. while the combined width of the three in mid-shaft is 9 mm. and that of metatarsal

¹*Procompsognathus triassicus* Fraas, 1913.

²Herr Gerhard Heilmann of Copenhagen, to whom that portion of the 1914 work describing *Podokesaurus* was submitted for criticism, says of my restoration of the animal (Fig. 25): "Professor Lull's placing of the pubis is not convincing, on the contrary, his description seems to make it still more probable, that this bone is entirely brought out of position, the ilium and the proximal end of the tail being totally wanting, and thus these must have been removed before the bones were covered by sand. Dr. R. W. Shufeldt supposes (in a letter) that the reptile may have been a subadult individual, and the prepubis not thoroughly coossified with the ilium and ischium in the cotyloid cavity. This seems very probable."

"A pubis protruding into the chest of the animal looks indeed too heterogeneous to be trustworthy." [Original author's translation, from Heilmann, 1913 B, p. 64.]

III alone 4 mm. One phalanx, the proximal one of digit III, measures 18 mm. long, the proximal end 6 mm. thick while the distal extremity is 4.5 mm.

I have compared the footprints of *Grallator cursorius* (see fig. 27) with the foot and stride of *Podokesaurus* with apparent conformity. *Grallator cursorius* is an abundant species associated in profusion with the huge *Otozoum moodii* from the quarry in South Hadley, so that geologically and geographically as well as anatomically the comparison seems justified.

In my restoration of *Podokesaurus* (fig. 25) I have added the skull, ilium, and a few other missing details from *Compsognathus* which, while not contemporaneous, is a conservative type and of this group the nearest in time to the dinosaur under discussion.

Podokesaurus was essentially a slender, cursorial animal, carnivorous in habits, but from the very slenderness which gave it such celerity of movement necessarily confined to feeble prey of which the various Newark footprints manifest so great an abundance. That it was related to the group represented later by *Ornitholestes* and *Ornithomimus* seems approximately certain.

THE FOOTPRINTS

The various species of the vertebrate footprints owe their authorship very largely to President Edward Hitchcock, who described and named nearly all of the known forms from the Newark rocks, a labor which extended over a period of almost thirty years. To his son, Professor C. H. Hitchcock, much credit is also due, not only for the description of a number of new species, especially from the New Jersey area, but for his careful cataloguing of the great Amherst College collection and the gathering and arrangement of that at Mount Holyoke College as well.

A brief historical statement of the footprint nomenclature seems necessary in order to clarify the complex synonymy which has risen.

The first paper describing these phenomena in the Connecticut valley is that by Edward Hitchcock in 1836—"Ornithichnology.—Description of the foot marks of birds, (Ornithichnites) on new red sandstone in Massachusetts;" Amer. Jour. Sci., (1), 29, pp. 307-340. In this publication Hitchcock says (p. 315):

"I include all the varieties of tracks under the term *Ornithichnites*; (*opvis* and *τεχνος* [sic]) signifying *stony bird tracks*; and if it be convenient to speak of the subject as a distinct branch of knowledge, I should call it *Ornithichnology*."

"All the varieties of tracks which I have discovered, I include under two divisions: 1, the *Pachydactyli*, or thick toed; 2, the *Leptodactyli*, or slender toed. . . . Under these divisions, I repose much confidence in the distinct existence of the following species and varieties. . . .

"When I speak of species here, I mean species in oryctology, not in ornithology. And I doubt not, that in perhaps every instance, what I call a species in the former science, would be a genus in the latter; that is to say, these different tracks were made by birds that were generically different."

Then follows the first specific list; to be followed in its turn by descriptions of all of the species enumerated. This list reads:

"ORNITHICHNITES.

1. *Pachydactyli*.

- O giganteus
O tuberosus
 a dubius

2. *Leptodactyli*.

- O ingens
 a minor
O diversus
 a clarus
O β platydactylus
O tetradactylus
O palmatus
O minimus"

It should be here noted that Hitchcock clearly describes the species, but that the higher names are based on ideas, not on any specific specimen, i. e., on "bird tracks," either "thick toed" or "slender toed." That this was his wish is also to be seen from his subsequent publications, cited beyond.

In 1837 the second paper upon the footprints appeared in the *American Journal of Science* ("Fossil footsteps in sandstone and gray-wacke"), (1), 32, pp. 174-176. In it Hitchcock said:

"I am now prepared to describe fourteen new species—double the number described in my first paper. . . . In general they are more distinctly marked upon the rock than those formerly described; and some of them bear in some respects so near a resemblance to the feet of living Saurians, that I have denominated them *Sauroidichnites*. But I have no certain evidence as yet, that any of them were made by four-footed animals, although in respect to two or three species I have strong suspicions that such was the fact. I have sometimes thought they might have been made by Pterodactyles. . . . I take the liberty to subjoin a catalogue of all the species hitherto discovered, according to a more comprehensive arrangement, which further discoveries have rendered necessary. . . .

"I arrange all the footmarks under the general term

ICHNITES (*ιχνος* and *λιθος*).

"The subdivisions are three.

1. *Tetrapodichnites*.
T. didactylus.
2. *Sauroidichnites*.
S. Barrattii [and other species].
3. *Ornithichnites*."

In this paper no descriptions are given, but these are reserved for the article of 1841, the "Final Report on the Geology of Massachusetts."

On page 476 of the latter publication, under the title, "Classification," Hitchcock says:

"So numerous have been the discoveries of fossil footmarks in Europe within a few years past, and so many species occur in this country, that it will be at least convenient to have them designated by some appropriate scientific terms, and to arrange them in systematic order. I propose the term *Ichnolite* (*ιχνος* a track, and *λιθος*, a stone) to include them all; and to be the name of the Class. I would divide this Class into Orders, depending upon the number of feet possessed by the animal that made the tracks: *Polypodichnites* (*πολυς, πους*, and *ιχνος*) to embrace those with more than four feet: *Tetrapodichnites*, those with four feet; and *Dipodichnites*, the bipeds. . . .

"I have arranged these species [*Dipodichnites*] under two sub-orders: the *Sauroidichnites* (*Σαυρος ειδος* and *ιχνος*) or those resembling the track of a Saurian, or lizard; and *Ornithoidichnites* (*Ορνις, ειδος* and *ιχνος*) or those resembling the track of a bird. These names, implying only a resemblance, leave the real nature of the tracks open to discussion in the sequel."

The paper of 1845 read before the Association of Geologists and Naturalists at a meeting held in New Haven in April of that year establishes genera of fossil footprints for the first time; for, as Hitchcock says (p. 23), "hitherto names have been given to the footmarks and not to the animals. But since all geologists now admit that these impressions are real tracks, this paper attempts to name the animals that made them, and to classify and describe them, so far as it can be done from the data hitherto obtained. The following synopsis shows the names and the classification; the latter being merely provisional."

This paper was actually accompanied by descriptions of each of the sixteen genera and thirty-five species included in the list, but the descriptions were not published until 1848, when they appeared in the "Fossil Footmarks of North America." Nevertheless each species re-enumerated was accompanied by a clear indication of the one referred to under the older nomenclature, so that this series of names—with two exceptions wherein new specific names were substituted for the old, (*Eubrontes*) *dananus* for (*Ornithoidichnites*) *sillimani*, and (*Polemarchus*) *gigas* for (*Sauroidichnites*) *polemarchius*, which of course

is unwarranted—must stand as a valid series of specific and generic names.

In 1848, in the publication just cited, Hitchcock again describes and figures the known sorts of footprints, but takes the liberty of changing the names (at that time the Candolle rules of nomenclature of 1844 had not been widely accepted) of certain of the genera and species proposed in the list of 1845, choosing to ignore that publication utterly, despite the facts that each name proposed was accompanied by a clear reference to previously described and figured species and that the vehicle of publication was an established journal of the highest rank. Such a procedure cannot now be followed, since the present rules of nomenclature are retroactive back to the publication of Linne's "Systema Naturæ," tenth edition, 1758. The names in this 1845 list, therefore, cannot be considered *nomina nuda*, and according to the laws of priority¹ must stand, with the specific exceptions already alluded to. In all subsequent publications by Edward Hitchcock and his son, Charles H. Hitchcock, and others down to that of Hay in 1902, the later names of 1848 unfortunately were used and have become as a consequence the familiar ones.

Hay in this work of 1902 made the first attempt at a revision of footprint nomenclature according to the present International Rules. So carefully was his work done that the writer has followed it closely, except where study of the actual tracks has brought to light new facts bearing on the synonymy; and it is hoped that the necessity for further literary revision of the nomenclature will be avoided. The carefully rendered advice of Professor Charles Schuchert and Doctor W. H. Dall, both of whom were high authorities in matters of nomenclature as defined in the International Rules, has been followed to the letter, and the weight of their sanction, coupled with that of Doctor Hay, seems sufficient to justify the generic and specific names used in this memoir.

The admirable revision of the genera and species by Doctor Hay in 1902, together with that of the author in 1904, the latter the result of several years' labor upon the collections at Amherst and Mount Holyoke, seems to obviate the necessity for more than a diagnostic review of the genera and species. I have endeavored, however, to figure each available species of vertebrate footprint found in the Connecticut valley and in New Jersey, while of the invertebrate trails only the most characteristic genera are thus treated. It is to be regretted that the Marsh collection at Yale is not at present fully accessible for study though many of the more easily handled slabs have been identified and catalogued. It is doubtful whether this collection would add materially to the list of species, though it would probably prove of

¹"The valid name of a genus or species can be only that name under which it was first designated in the condition:

"a. That this name was published and accompanied by an indication, or a definition, or a description" (Internat. Rules Zool. Nomenclature, Art. 25).

"The word 'indication' in Art. 25a is to be construed as follows:

"(B) With regard to generic names . . . a definite citation of an earlier name for which a new name is proposed" (*Ibid.*, Opinion i B).

the highest importance in the further elucidation of forms already named but obscurely known.

It has been deemed wise, even where with fair assurance one can correlate the tracks with the osseous remains of the animal that made them, to keep the ichnite genera and species apart in their nomenclature from that applied to the actual bones, for it is at once apparent to the student of ichnology that footprint genera and species do not necessarily correspond in limitations or numbers with those of the actual animals which made the impressions. The genera *Anchisaurus* and *Ammosaurus*, for example, though generically separable in the bones, made tracks which according to ichnological criteria can only be distinguished specifically; and I am quite sure, when I study the range of variation within the footprint species *Anchisauripus sillimani* (*Brontozoum sillimanium*), that more than one osseous form is required to account for it. One must always consider, too, the element of just scepticism with which any correlation of tracks and bones may be met, unless, as in the case of the Old World *Iguanodon*, the two are in exclusive association with each other.

Thus, even though in certain instances two names do apply to one animal, the avoidance of confusion and the greater approximation to facts justify what would otherwise be an unwarrantable practice.

With few exceptions the fossil footprints of Newark time cannot be placed in a zoological sequence of classification corresponding to that of animals known from their skeletal remains; for while many such are known elsewhere of equivalent geological age, very few are actually preserved in the rocks of the Connecticut valley and there is never an association of bones and footprints occurring in such proximity that direct evidence of relationship can be assumed as proven.

The morphology of certain of the footprints, especially in that group which Hitchcock called pachydactylous or thick-toed birds, shows them to be of undoubted dinosaurian origin, but there any degree of certainty fails, and while presumptive relationship with certain other reptilian orders seems likely, the evidence is more circumstantial than direct. Yet other footprints which are in the majority are such that they may only be grouped according to gait, trackway, and the number of impressed digits without any attempt to correlate them with the zoologic classification, for to do so would be merely a hazardous guess with no evidence of exactitude.

This is the principal reason why names given in Ichnology must be kept in a separate series which, were the trackmakers actually known, might result in two names given to the same animal, regrettable but unavoidable. The chances of the actual happening of such an occurrence are extremely remote.

The possibilities of time and space seem to debar the two higher classes of vertebrates, Aves and Mammalia, from the terrestrial vertebrate fauna of the Connecticut valley Triassic, which leaves either

amphibian or reptilian forms as possible makers of the trackways of Newark time. With rare exceptions the footprints themselves throw little light on the position of their makers in the zoölogic scale, even when the footprint is sufficiently clear to give a clue to the morphology of the foot that impressed it. For the others, one gropes in the dark for evidence of the character of the animal. Some of the tracks are undoubtedly so altered by the nature of the sediment or of the circumstances under which the foot was impressed, that one cannot even visualise the form of the foot itself. Doubtless some of the feet were abnormal due to accident or otherwise; but such must be a very small percentage of the denizens of the valley. The assumption is, therefore, that the trackways were made by normal animals such as they were and, aside from accidents of impression and subsequent preservation, the footprints should be recognizable as those of living forms, either amphibians or reptiles.

The most satisfactory method of classification therefore must depend upon such factors as the gait of the trackmaker, whether quadrupedal or bipedal, and, if the latter, whether habitually so or merely occasionally, as in the case of certain modern lizards when impelled by the necessity for greater speed.

The posture of the feet, whether digitigrade or plantigrade, must depend in certain instances upon the gait of the animal, depending once more upon the necessity for rapid movement.

Finally, the number of digits, which of course cannot be fewer than those impressed, may easily be more up to four or five in the actual foot, as in the case of the occasional indication of a hallux claw impressed by what is functionally a three-toed foot. Phalangeal pad and claw imprints may not always leave evidence of their existence, because of subsequent slumping of the mud upon the withdrawal of the foot. In other words, negative evidence is never so trustworthy as positive or complete impressions such as many of them are, and certain so-called leptodactylous or narrow-toed tracks may well have been made by the same forms that in other circumstances are adequately impressed and described under a very different generic or specific name.

Among variable factors, which, nevertheless, have been described for what they are worth, are the length of pace, which in the same species may change rapidly with the acceleration of the gait; and the divarication of the digits may vary in the successive tracks of the same foot. Finally, when two described species of the same genus differ but little except in size, the age factor should be taken into consideration and the differences accounted for by seasonal growth and not actual specific distinction. This is especially likely when two described species are impressed upon the same slab and are therefore contemporaneous, as in the case of *Anchisauripus sillimani* and *A. hitchcocki* on the remarkable Middletown specimen (see fig. 38).

VARIOUS CLASSIFICATIONS

HITCHCOCK'S FINAL CLASSIFICATION

President Hitchcock, the founder of the science of Ichnology, still ranks as our highest authority in the study of these relics of the past, for none has had the opportunity or a keener insight into the various characteristics of the footprints greater than he, even after a lapse of nearly one hundred years.

Hitchcock sought to arrange the makers of the footprints according to his conception of existing vertebrates, for so few contemporary osseous species were known at that time, that they were rarely taken into consideration as possible trackmakers.

A synopsis of the genera and species printed in 1865 (?) reads as follows:

Group I. *Marsupialoid animals*.

Genera: *Cunichnoides*, *Anomæpus* and *Anisopus* [*Batrachopus*].

These, on account of their apparent quadrupedal gait and narrow trackway, except for the first, were supposed to have been the trails of mammals and, because of their antiquity, necessarily marsupials.

Group II. *Pachydactylous or Thick-toed Birds*.

Including the genera *Brontozoum* [*Eubrontes*], *Amblonyx*, *Grallator*, *Leptonyx* [*Stenonyx*] and *Comptichnus*. So bird-like were some of these tracks that Hitchcock, having little or no knowledge of the dinosaurs, attributed the tracks to avian origin and the popular name of "Bird tracks" clung to these genera for years.

Group III. *Leptodactylous or Narrow-toed Birds*.

Including those forms whose digits were very narrow, showing no trace of phalangeal pads or other morphologic details, largely due to the character of the soft sediment and, therefore giving little indication of the actual form of the feet. This group was divided into two subgroups:

I. Tridactylous or three-toed forms including *Argozoum* [*Argoides*] and *Platypterna*, and

II. Tetradactylous—in which a fourth digit was impressed—Genera *Ornithopus* [*Sillimanius*] and *Tridentipes*.

Group IV. *Ornithoid Lizards or Batrachians*.

Including *Gigantitherium* (*Gigandipus*), *Hyphepus*, *Corvipes*, *Tarsoedactylus*, *Apatichnus*, *Trihamus*, *Anticheiropus* and *Plesiornis* with, under *Incertæ sedis*, the lone genus *Typopus*. Most of these forms were bipedal although the genus *Plesiornis* was later considered a quadruped. But why such a huge bipedal animal as *Gigandipus* was thought to be a batrachian is not evident.

Group V. *Lizards*.

Again including both bipeds and quadrupeds such as the huge

Polemarchus, and the lesser *Plectropterna*, *Trianopus*, *Harpedactylus*, *Toxichnus*, *Xiphopeza*, *Orthodactylus*, *Antipus*, *Stenodactylus* (*Sustenodactylus*), *Arachnichnus*, *Chimæra* (*Sauropus*) and *Isocampe*.

That some of this group were lizard-like in proportions and gait is certainly true—whether any of them were true lizards is not demonstrable.

Group VI. *Batrachians*.

Of these, *Batrachoides* was attributed to nests made by tadpoles, but is generally thought to be simply two cross series of symmetrical ripple-marks which are formed to this day where favorable cross currents of water occur and in which existing tadpoles may find refuge. But they were not of organic origin. *Otozoum*, again one of the largest and most remarkable of these phenomena, is clearly not batrachian but pertains to a huge bipedal plantigrade form, clearly of dinosaurian relationship. *Palamopus*, *Macropterna*, *Cheirotheroides*, *Shepardia*, *Lagunculapes*, *Selenichnus* are included, but the last is again a bipedal dinosaur-like form, while *Hoplichnus* seems due to physical, rather than organic origin. *Saltator* may have been an invertebrate.

Group VII. *Chelonians*.

Here Hitchcock placed the genera *Ancyropus*, *Chelonoides*, *Helcura*, *Exocampe*, and *Amblypus*; a varying group whose claim to Chelonian origin is rather vague, depending largely upon the gait and wide track-way for evidence.

CLASSIFICATION OF LULL 1915

Class Reptilia

Order Parasuchia

Suborder Aëtosauria

Fam. Batrachopodidæ, *Batrachopus*, *Cheirotheroides*

Order Dinosauria

Suborder Theropoda

Fam. Anchisauripodidæ, *Anchisauripus*

Fam. Otouphepodidæ, *Otouphepus*

Fam. Gigandipodidæ, *Gigandipus*, *Hyphepus*

Fam. Eubrontidæ, *Eubrontes*

Fam. Grallatoridæ, *Grallator*, *Stenonyx*

Fam. Selenichnidæ, *Selenichnus*

Suborder Orthopoda

Fam. Anomæpodidæ, *Anomæpus*, *Sauropus*, *Apatichnus*

Fam. Otozoidæ, *Otozoum*, ?*Cheirotherium*

Reptilia Incertae sedis

Forms Habitually Bipedal

Genera *Platypterna**Argoides**Plectropterna**Polemarchus**Plesiornis* (part)*Sillimanius**Steropoides**Lagunculapes*

Doubtful

*Trianopus**Toxichnus*

Forms Occasionally Quadrupedal

Genera *Xiphopeza**Tarsodactylus**Harpedactylus*

Forms Habitually Quadrupedal

Genera *Corvipes*, *Ancyropus*, *Chelonoides*,*Amblypus* (*Helcura?*),*Eupalamopus*, *Palamopus*, *Exocampe*, *Orthodactylus*,*Antipus*, *Sustenodactylus*, *Isocampe*, *Shepardia*, *Comptichnus*,*Arachnichnus*

A revision of the classification of 1915 will, it is hoped, approximate more nearly to fact for the distinctively dinosaurian trails, but beyond these one comes to an arrangement into groups based upon obvious characters. No attempt at a zoological interpretation can be based upon direct evidence. It is given for convenience of reference only. A classification of fossil forms after Romer with such correlation of the footprints as may safely be assumed will be given first, followed by an arrangement and grouping of the footprints which will be followed in the discussion of the ichnite genera and species.

REVISED CLASSIFICATION OF LULL 1933

Trackways

Zoological Group

BIPEDAL FORMS

Order Saurischia

Group I. a. Small, tridactyl, digitigrade;
no manus or hallux imprint.Suborder Theropoda
Infraorder Cœlurosauria

Pace long. Trackway narrow

Fam. Podokesauridae

*Grallator**Stenonyx**Selenichnus**?Plesiornis pilulatus*

- | | |
|---|---|
| b. Medium-sized; hallux present | Fam. Anchisauridae |
| <i>Anchisauripus</i> | |
| <i>Otouphepus</i> | |
| Group II. Large, digitigrade, functionally tridactyl, no manus imprint. Hallux sometimes impressing | Infraorder Carnosauria |
| a. Tridactyl. No hallux | |
| <i>Eubrontes</i> | |
| b. Tetradactyl, with hallux | |
| <i>Gigandipus</i> | |
| <i>Hyphepus</i> (Small, ?web-footed) | |
| Group III. Huge; gait bipedal, manus track while resting. Pes plantigrade, tetradactyl, manus tetradactyl or pentadactyl | Infraorder Prosauropoda |
| <i>Otozoum</i> | |
| Group IV. Moderate size; gait bipedal. Digitigrade in motion. Plantigrade with elongate tarsal (heel) imprint and generally with manus imprint when at rest. Pes, tetradactyl; manus, pentadactyl | Order Ornithischia
Suborder Ornithopoda
Family? Hypsodontidae |
| <i>Anomæpus</i> | |
| <i>Sauropus</i> | |
| <i>Apatichnus</i> | |
| Group V. Bipedal, no manus imprint. Tri- or tetradactyl, digitigrade. Short stride; medium trackway | ? |
| <i>Lagunculapes</i> | |
| <i>Toxichnus</i> | |
| Group VI. Bipedal, tetradactyl, digitigrade. No manus imprint | ? |
| Large | |
| <i>Anticheiropus</i> | |
| <i>Polemarchus</i> | |
| Small to medium | |
| <i>Sillimanius</i> | |
| <i>Eupalamopus</i> | |
| Group VII. Bipedal, no manus, tri- or tetradactyl; semi-digitigrade to plantigrade. | ? |

Pace moderate. Trackway medium to wide

Platypterna

Argoides

Steropoides

Trihamus

QUADRUPEDAL FORMS

Group VIII. Quadrupedal, tetradactyl manus and pes digitigrade to semi-plantigrade.
Pace generally long; narrow trackway, feet almost in line

Suborder Pseudosuchia
Fam. Steganolepidae

Batrachopus

Cheirotheroides

Comptichnus

Shepardia

?*Antipus*

Group IX. Habitually quadrupedal. Pes plantigrade, tridactyl or tetradactyl; manus much smaller than the pes and pentadactyl.
Pace short; trackway medium to wide; sprawling

?

Ammopus

Corvipes

Palamopus

Group X. Habitually quadrupedal. Pes tetradactyl with well developed hallux. Manus, tri- to pentadactyl; manus impression varies from very light with only the tips of the digits showing to full with an elongated carpus.
Pace short; trackway medium to wide

Plectropterna

Harpedactylus

Exocampe

Tarsodactylus

Xiphopeza

Group XI. Habitually quadrupedal. Pes plantigrade, pentadactyl. Manus pentadactyl, generally deeply impressed.

Pace generally short. Trackway medium to very wide. Sprawling gait

Chelonoides

Arachnichnus

Sustenodactylus

Possibly Amphibian

Group XII. Quadrupedal.

Pes digitigrade, tetradactyl; manus, tetra- or pentadactyl.

Tracks abnormal due to slipping or toe dragging.

Pace short. Trackway medium. Tracks without morphologic character

Orthodactylus

Isocampe

Group XIII. Miscellaneous obscure forms

Cunichnoides

Amblypus

Ancyropus

Triænopus

Typopus

Antipus

✓ Class REPTILIA

Order SAURISCHIA

Suborder Theropoda. Carnivorous dinosaurs

Infraorder Coelurosauria

Group I: Strictly bipedal, digitigrade forms small to moderate size. Manus never impressing, pes tridactyl, hallux imprint absent, or when present rotated to the rear. Pace relatively very long; trackway narrow.

Family GRALLATORIDÆ

Family Characters.—Typically small, footprint tridactyl, limbs very long.

Without tail trace: *Grallator*, *Stenonyx*.

With tail trace: *Selenichnus*.



FIGURE 26.
Grallator,
Trackway original.
One-fifth natural size.

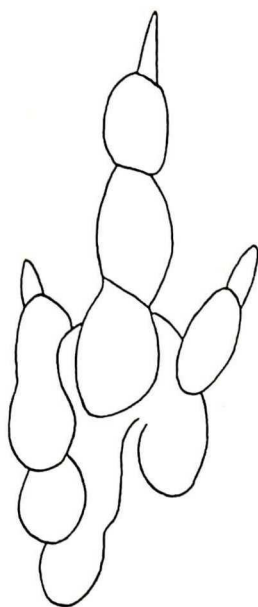


FIGURE 27.
Grallator cursorius
Hitchcock after Lull, from
the type Cat. No. 4/1 A. C.
natural size.

Genus *Grallator* E. Hitchcock

E. Hitchcock 1858, p. 72.

Lull 1904A, p. 494; 1915, p. 206.

Generic Characters:—Typically small, bipedal forms; footprints tridactyl, feet small, compact, with distinct phalangeal pads and well-developed, acuminate claws. Limbs very long, no manus or caudal impressions.

Distinguished from *Anchisauripus*, which it most closely resembles, by greater relative length of stride, smallness of track, and the absence of a hallux impression.

The several species which are now or have been assigned to this genus are:

Grallator cursorius (genotype), *G. tenuis*, *G. gracilis*, *G. gracillimus*, *G. cuneatus*, *G. formosus*, and *G. parallelus*.

Discussion:—Of these the first three are the most typical of the genus and are separated by a wide dimensional factor from the last three.

Grallator gracillimus is now referred to the genus *Anomæpus*, and *G. parallelus* to the genus *Anchisauripus*.

The discovery of the osseous remains of the dinosaur *Podokesaurus* reveals a form which, as now interpreted, may well have made tracks comparable in dimensions to those of *Grallator cursorius*. This again is a statement void of factual proof, for no direct association of skeleton and footprint is known in the Connecticut valley comparable to the Iguanodon skeletons and associated footprints from the Cretaceous (Wealden) of the Isle of Wight and from Hastings, Bexhill, and Swanage in Britain.

10 *Grallator cursorius* E. Hitchcock

E. Hitchcock 1858, p. 72, pl. 13, fig. 3; pl. 33, fig. 5; pl. 58, fig. 4. Lull 1904A, p. 494, figs. 12, 13; 1915, p. 200, fig. 53.

Holotype;—Cat. No. 4/1 A. C.; large slab of coarse, reddish sandstone from Moody's Corner, South Hadley, Mass. Associated with *Otozoum moodii* and *Anchisauripus sillimani*, and *Grallator formosus*.

Specific Characters:—Small, compact foot with distinct phalangeal pads, and acuminate claws. Dimensions: Pes: length of digit II, 35 mm.; of III, 55 mm.; of IV, 45 mm.; of the foot, 79 mm.; between lateral tips, 33 mm. Projection of digit III beyond the other toes, 30 mm.

Divarication of digits II and III, 14°; of III and IV, 12°; of the lateral digits, II and IV, 26°.

Length of pace 370 mm. Width of trackway 50 mm.

Ratio of foot to pace as 1 to 4.66; of foot to stride, about 1 to 8.

Pes angulation, 0°.

Localities:—Turners Falls, Field's orchard in Gill, Moody's Corner, South Hadley, Mass.; Wethersfield, Portland, Middletown, and Middlefield, Conn. Also Milford and Whitehall, N. J.

A very widespread species.

Geological Distribution:—Upper shales (Middlefield) and upper (Portland) series of shales, etc.

11 *Grallator tenuis* E. Hitchcock

E. Hitchcock 1858, p. 73, pl. 13, fig. 4; pl. 53, fig. 5.

Lull 1904A, p. 495, fig. 14; 1915, p. 201, fig. 54.

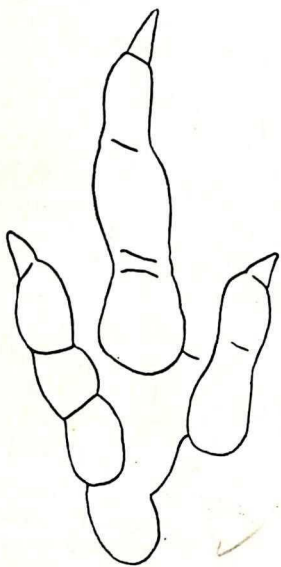


FIGURE 28.

Grallator tenuis Hitchcock
from Cat. No. 17/4 A. C.
after Lull, natural size.

Holotype:—Cat. Nos. 12/3 and 12/4 A. C., counterparts, on red shale from Turners Falls, Mass. In close proximity to the trap sheet.

Also No. 17/4 A. C., on red shale, from the Ferry above Turners Falls. Described and figured by Lull, hence a plesiotype.

Specific Characters:—Pes: Length of digit II, 30 mm.; of III, 49 mm.; of IV, 45 mm.; of the foot, 73 mm.; between lateral tips, 37 mm. Projection of digit III beyond the lateral toe, 28 mm. Divarication of digits II and III, 15° – 25° ; of III and IV, 25° to 28° ; of the lateral digits, II and IV, 40° to 45° .

Length of pace, 195 mm.; width of the trackway, 63 mm.

Ratio between foot and pace, 1 to 2.7 (1 to 3.3 type).

Pes angulation, 0° to 5° . Distance between mid-heels, 12 mm.

Localities:—Turners Falls; stream near Pliny Moody's in South Hadley, Mass.; Wethersfield, Portland, and Middletown, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion:—The chief distinctions between this form and *G. cursorius* lie in the shorter stride, smaller ratio between foot and step, and the greater divarication of the toes of the present species. Both these are variable quantities. It is extremely difficult, especially when but a single imprint is present, to determine to which species it may belong.

If, as may prove the case, they are variants of the same species, *G. cursorius* has priority and *tenuis* becomes a synonym.

Grallator gracilis C. H. Hitchcock

C. H. Hitchcock in E. Hitchcock 1865, p. 8, pl. 9, fig. 7.

Lull 1904A, p. 496, fig. 17; 1915, p. 202, fig. 55.

Holotype:—Cat. No. 17/2 A. C., on red shale from Turners Falls.

Plesiotype:—Cat. No. 23/8, on red, micaceous sandstone also from Turners Falls.

Specific Characters:—Pes: Length of digit II, 21 to 26 mm.; of III, 32.5 to 35 mm.; of IV, 25 to 30 mm.; of the foot, 45 mm.; between lateral tips, 23.5 to 27 mm. (first figure from holotype, second from No. 23/8 A.C.). Projection of digit III beyond the others, 18 mm. Divarication of digits II and III, 22° to 28° , of III and IV, 14° to 16° ; of the lateral digits, II and IV, 35° to 40° .

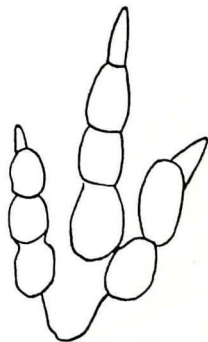


FIGURE 29.
Grallator gracilis
C. H. Hitchcock
from Cat. No. 23/8
A. C. after Lull,
natural size.

Length of stride, 278 to 315 mm.; of pace, 158 mm.

Width of trackway, 40 mm.

Ratio of foot to stride, as 1 to 7; of foot to pace, as 1 to 3.22.

Localities:—Ferry above and at Turners Falls, also in Gill, Fields orchard in Gill, Mass. Portland, Conn., and Milford, N. J.

Geological Distribution:—Upper (Portland) series in the Connecticut valley.

Discussion:—*Grallator gracilis* is the smallest of the species and represents one of the most diminutive of dinosaurs.

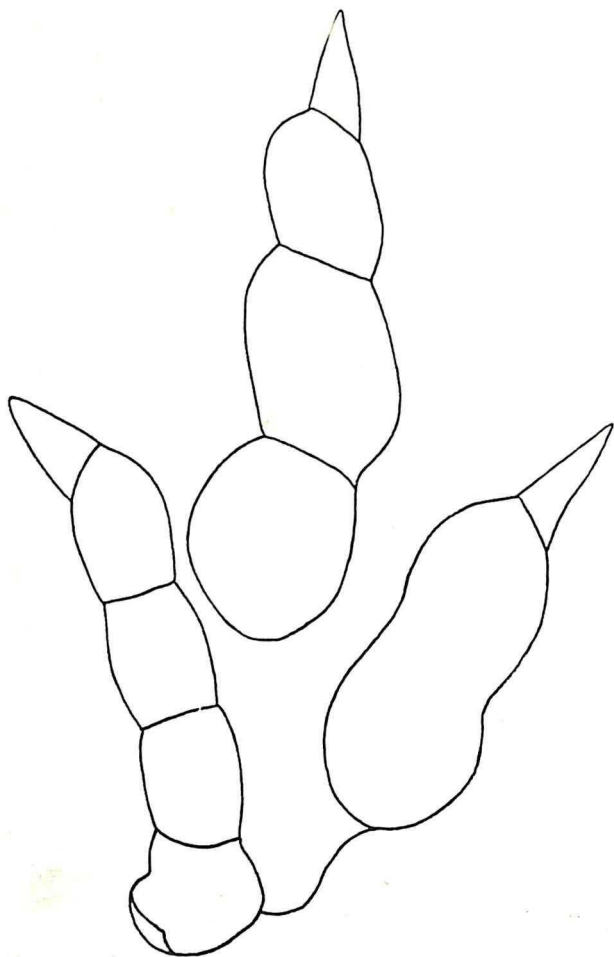


FIGURE 30.
Grallator cuneatus Hitchcock from Cat. No. 17/1 A. C.
after Lull, natural size.

Grallator cuneatus E. Hitchcock

E. Hitchcock 1858, p. 74, pl. 13, figs. 1,3; pl. 41, figs. 1,2.

Lull 1904A, p. 495, fig. 15; 1915, p. 202, fig. 56.

Holotype.—Cat. No. 25/1 A. C., on red shale from the Lily Pond, Gill, Mass.

Plesiotype.—Figured by Lull, Cat. No. 17/15 A. C., from Turners Falls, Mass.

Specific Characters.—Pes: Length of digit II, 55-63 mm.; of III, 93 to 81 mm.; of IV, 78 to 74 mm. Projection of digit III, beyond the others, 55 to 51 mm.; between lateral tips, 73 to 80 mm. Length of the foot, 126 to 125 mm. Divarication of digits II and III, 12° to 25° ; of III and IV, 16° to 23° ; of the lateral digits, II and IV, 28° to 46° .

Length of the step, 559 to 609 mm. and 460 to 550 mm.

Width of trackway, 87 to 90 mm.

Ratio of foot to step, as 1 to 4.8 and 1 to 4.4.

The first figures are from Hitchcock, holotype No. 252, the second from Lull, figured specimen No. 17/15 A. C.

Pes angulation, 0° .

Between mid-heels, 25 mm.

Localities.—Horse Race, Lily Pond and Field's orchard in Gill, Ferry above Turners Falls, Turners Falls, South Hadley, Chicopee Falls, Mass; Wethersfield and Wethersfield Cove, Conn; Milford, N. J.

Geologically confined to upper (Portland) series.

Discussion.—*Grallator cuneatus* is much larger than the three preceding species and is about equal in size to *Anchisauripus sillimani*, but is distinguished from the latter by the greater projection of the middle toe, the lack of hallux imprint, and the generally cuneiform shape of the foot which is heightened by the bending outward of the lateral claws.

Grallator formosus E. Hitchcock

E. Hitchcock 1858, p. 75, text fig. 2; pl. 39, fig. 1; pl. 60, fig. 1.

Lull 1904A, p. 496, fig. 16; 1915, p. 205, fig. 57.

Holotype.—Cat. No. 3/1 A. C., on a large slab from Moody's corner. Associated with *Otozoum moodii*. Counterpart of No. 4/1 A. C.

Specific Description.—Pes: Length of digit II, 98 to 75 mm.; of III, 126 to 118 mm.; of IV, 111 to 114 mm.; of the foot, 185 to 172 mm.; between lateral tips, 111 to 110 mm.; projection of digit III

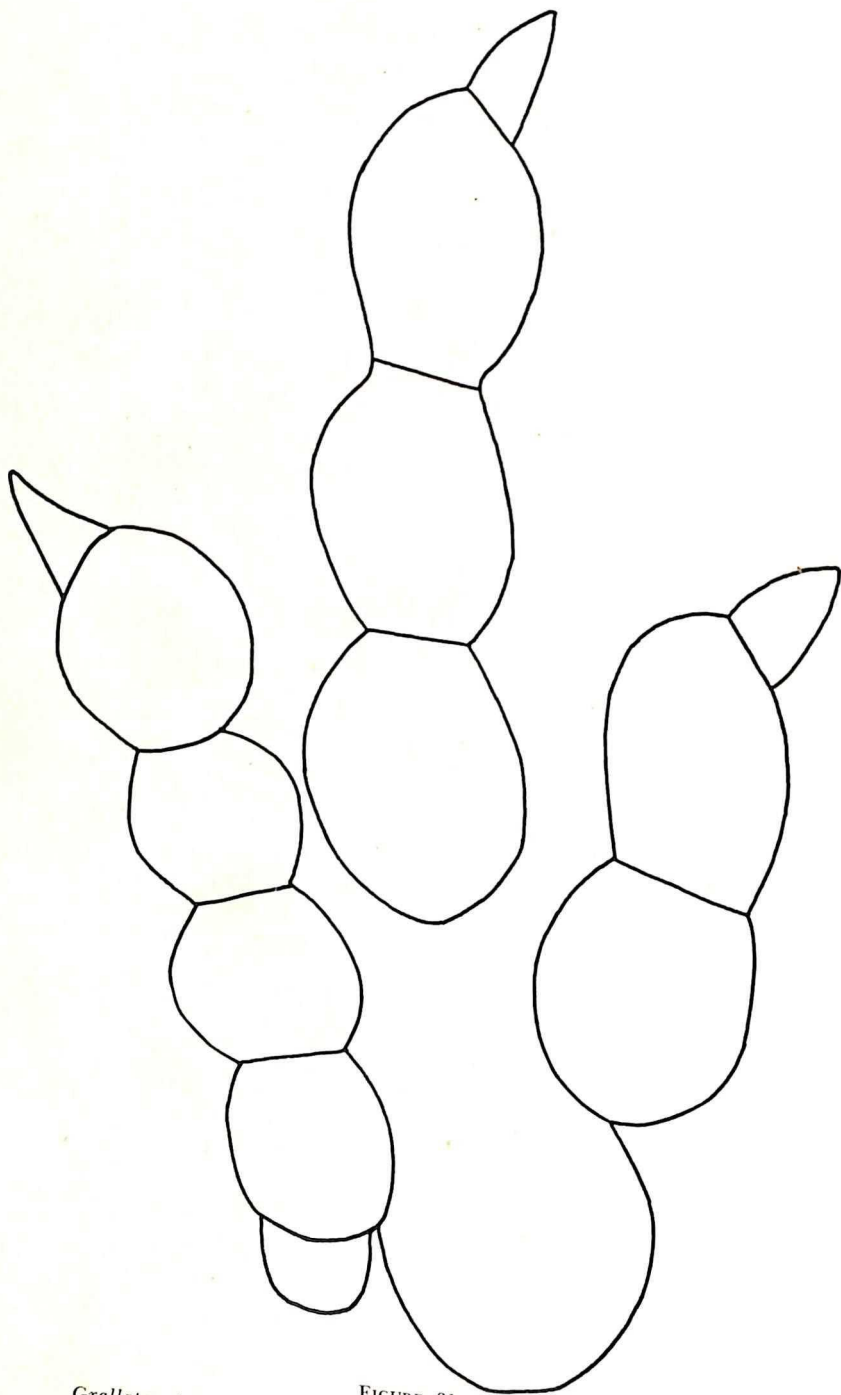


FIGURE 31.
Grallator formosus Hitchcock from the type, Cat. No. 3/1 A. C.
after Lull, natural size.

beyond the lateral toes, 76 to 68 mm. Divarication of digits II and III, 20° to 11.5° , of III and IV, 32° to 21.5° ; of the lateral digits, II and IV, 55° to 33° .

Length of step (pace), 685 to 655 mm. Width of trackway, 152 mm. Ratio of foot to pace, as 1 to 3.8.

First figure, Hitchcock's; the second, Lull's.

Pes angulation, 4° inward.

Localities:—Lily Pond, Field's orchard, Gill; Smiths Ferry, Moody's Corner and stream near Pliny Moody's, South Hadley; Chicopee Falls, Mass. Wethersfield and Middletown, Conn. Upper (Portland) series, North Branford, Conn. Upper (posterior) shales. Whitehall, N. J.

Discussion:—This species is very large for a *Grallator*, approaching *Anchisauripus sillimanii* in size. The ratio of foot to pace, about 1 to 3.8, approaches that of *Grallator tenuis* but is smaller than the typical species *cursorius* in which it is as 1 to 4.6. Its inclusion within the genus *Grallator* is questionable.

Stenonyx Lull

For *Leptonyx* E. Hitchcock 1865, p. 8 (name preoccupied).

Lull 1904A, p. 498; 1915, p. 205.

Generic Characters:—Small, bipedal forms, tridactyl (or tetradactyl), digitigrade. Toes thick with distinct phalangeal pads. Claws long and slender, stride fairly short. No tail trace.

Discussion:—But one species of this rare genus has been described: *Stenonyx lateralis* (E. Hitchcock), the genotype, represented by but two recorded specimens in the Amherst collection and four in that of Yale.

Stenonyx lateralis (E. Hitchcock)

E. Hitchcock 1865, p. 8, pl. 5, fig. 3
(*Leptonyx*).

Lull 1904A, p. 498; 1915, p. 205, fig. 58.

Holotype:—Cat. No. 47/40 A. C., from Turners Falls, Mass.

Specific Characters:—Pes: Length of digit II, 15 mm.; of III, 17 mm.; of IV, 16 mm.; of the foot, 30 mm.; between lateral tips, 21 mm. Projection of digit III beyond the lateral toe, 11 mm. Divarication of digits II and III, 32° ; of III and IV, 28° ; of the lateral digits, II and IV, 60° .

As the type is an isolated track no further measurements are possible.

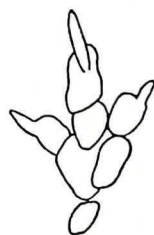


FIGURE 32.
Stenonyx lateralis
(Hitchcock)
after Hitchcock,
natural size.

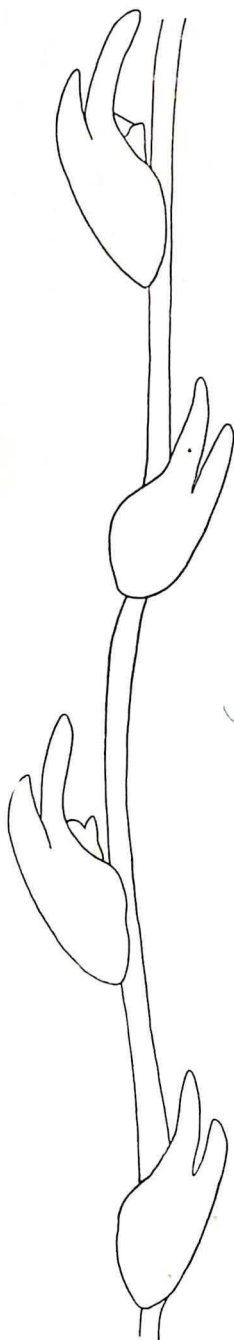


FIGURE 33.
Selenichnus
trackway, original
one-half natural size.

From Cat. No. 2049 Y.P.M., which agrees with the type in several dimensions, the length of the pace may be given as ± 73 mm.; width of the trackway, 32 mm. Ratio of foot to pace, as 1 to 3.65.

Claws, very long and slender, arising, in the type, from the median side of digits II and III and from the outer side of digit IV, hence the specific name *lateralis*. This character is not invariable, however, in the several Yale specimens which have been referred to this species.

Localities:—Turners Falls and the Lily Pond, Gill, Massachusetts.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Stenonyx* represents a small, bipedal form resembling *Grallator gracilis*, but it is much smaller and differs chiefly in the character of the claws.

Family SELENICHNIDÆ

Family Characters:—Bipedal, tridactylous, inner toe rarely distinct. Digits without pads or distinct claws. Tail trace always present, generally continuous, straight or slightly sinuous. A very striking trackway which, though obscure in detail, is readily recognizable.

Genus *Selenichnus* E. Hitchcock

E. Hitchcock 1858, p. 133.

Lull 1904A, p. 498; 1915, p. 206.

Generic Characters:—Those of the family.

Including two species, *Selenichnus falcatus* and *S. brevisculus* of which the first is the genotype.

Selenichnus falcatus Hitchcock

E. Hitchcock 1858, p. 133, pl. 23, fig. 8; pl. 60, fig. 8.

Lull 1904A, p. 498; 1915, p. 206, fig. 16.

Holotype:—Cat. No. 42/6 A. C. Slab of red sandstone showing one row of fifteen depressed tracks of the hind feet and one fore foot; with a very distinct tail trace. From the ferry at Turners Falls, Mass. A unique specimen. Cat. No. 42/7 is part of the same specimen.

Specific Characters:—Manus: Too obscure for description.

Pes: Tridactyl, semi-plantigrade. Length of digits measured from rear extremity of track: digit II, 36 mm.; III, 72 mm.; IV, 56 mm. Length of foot, 70 mm. Toes, curved inward, especially digit III; toes with rounded tips. Width of foot, 12 mm.

Length of pace, 88 mm.; of stride, 170 mm. Width of trackway, 63 mm.

Ratio of foot to pace, as 1 to 1.22.

Pes angle, 10° to 20° outward, heel usually on the median line.

Tail trace continuous and nearly straight; width, 5 mm.

Localities:—Ferry at Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

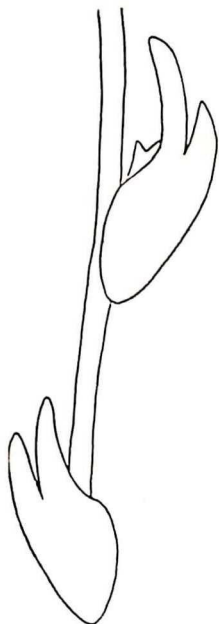


FIGURE 34.

Selenichnus falcatus
Hitchcock, after Lull,
one-half natural size.

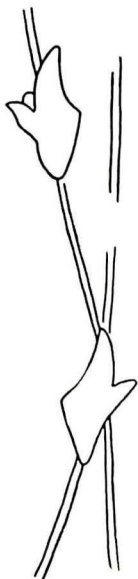


FIGURE 35.

Selenichnus brevisculus
Hitchcock, after Lull,
one-half natural size.
The tail was raised
and impressed a
second time during
the stride.

Selenichnus brevisculus E. Hitchcock

E. Hitchcock 1858, p. 134, pl. 23, fig. 9;
pl. 60, fig. 7.

Lull 1904A, p. 499; 1915, p. 207, fig. 60.

Holotype:—Cat. No. 44/10 A.C. A rain-marked slab, with a series of 23 tracks passing in a curved line across it. From Turners Falls, Mass.

Specific Characters:—Similar to *S. falcatus* in most respects, except for its smaller size and relatively shorter outer toe. (omit II)

Length of digit III, from extremity of heel, 36 mm.; of IV, 24 mm.; of the foot, 40-43 mm. Width of foot, 12 mm.

Length of pace, 40 to 58 mm. (70 from Lull's figure).

Width of trackway, 38 mm.

Tail trace not always continuous.

Pes angle, 0° to 10° outward.

Pace angle, 177° . (omit)

Ratio of foot to pace, as 1 to 2.

Locality:—The genus *Selenichnus* is known only from the Turners Falls region, both species sometimes occurring on the slab as in Cat. No. 42/6 A. C.

Geological Distribution:—Upper (Portland) series.

Genus *Plesiornis* E. Hitchcock

E. Hitchcock 1858, p. 102.

Lull 1904A, p. 521; 1915, p. 236.

Generic Characters:—Bipedal, tridactyl, digitigrade forms. Phalangeal pad impressions together with blunt or pellet-like claw mark occasionally present in the tracks.

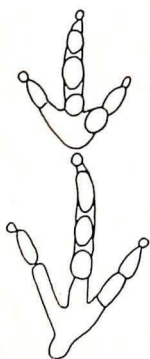


FIGURE 36.
Plesiornis pilulatus
Hitchcock from Cat.
No. 13/1 A. C.
after Lull,
one-half natural size.

At least six specific names have been given to so-called *Plesiornis* forms, some of which are synonymous within the genus and all may be referred to other genera and species of previously described bipedal footprints, with the possible exception of *Plesiornis pilulatus*.

Discussion:—Hitchcock's original description of *Plesiornis* follows: "Tridactylous, pachydactylous, hind foot slightly the largest. Toes slightly turned towards the line of direction; terminated by blunt claws or pellets. Highly ornithoid, the tracks distinguished from those of birds only by being arranged two by two along the median line, with a wide interval between."

Nowhere does Hitchcock mention the possibility of sex variation in defining his species, although he occasionally refers to marked difference in size of otherwise similar footprints as possibly being interpreted as age variation, but he apparently never accepts it as such. Where there is disparity of size in associated pairs of tracks having the same length of step, might they not be considered as a sexual pair the walking one behind the other, rather than the fore and hind feet of the same individual, especially when they both show the morphology of hind feet?

Plesiornis pilulatus E. Hitchcock

E. Hitchcock 1858, p. 103, pl. 17, fig. 8; pl. 36, fig. 4.

Lull 1904A, p. 501; 1915, p. 230, fig. 91.

Holotype:—Cat. No. 13/1 A. C., on gray sandstone, from Turners Falls, Mass.

Specific Characters:—(from C. H. Hitchcock) Manus: [Pes of one animal] Length of digit II, 23 mm.; of III, 35 mm.; of IV, 23 mm.; of

Length of digit II, 23-25 mm.; of III, 35-42 mm.; of IV, 23-27 mm.
Length of foot, 35-53 mm.
Width, 27-31 mm.

the foot, 35 mm.; between lateral tips, 27 mm. Divarication of digits II and III, 40°; of III and IV, 30°; of the lateral digits, II and IV, 70°.

Pes: [of the second animal] Length of digit II, 33 mm.; of III, 42 mm.; of IV, 38 mm.; of the foot, 53 mm.; between lateral tips, 38 mm.

Divarication of digits II and III, 40°; of III and IV, 30°; of the lateral digits, II and IV, 70°.

Length of pace, 183 mm.; width of trackway, 50 mm.

Ratio of foot to pace, as 1 to 3.45. *Pes* angle 0°; feet nearly in a right line.

Localities:—Turners Falls and Gill, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—The digits terminate in pellet-like claw marks and the so-called fore and hind prints are similar except that the latter is somewhat the larger and shows a spur or heel-like projection. The forward track is a little in advance of the hinder one, sometimes a little to the side, and again the two may interfere. The tracks are almost in a right line, with no *pes* angulation.

Plesiornis pilulatus is apparently not to be correlated with any other described form and must stand, but the description applies to two animals and not to a quadruped.

Plesiornis pilulatus may be redefined as follows: "Small bipedal, tridactyl, digitigrade forms, with blunt or pellet-like claws and occasional phalangeal impressions and a spur-like heel projecting from the inner rear portion of the track comparable to a backward continuation of digit IV.

(OMIT) *Plesiornis æqualipes* E. Hitchcock

Ornithoidichnites minimus E. Hitchcock 1841, p. 145, pl. 15, fig. 41.

Argozoum minimum E. Hitchcock 1848, p. 187, pl. VI, fig. 5.

Argoides minimus Lull 1904A, p. 518; 1915, p. 230, fig. 84.

E. Hitchcock, 1858, p. 104, text figure.

Holotype:—Cat. No. 31/7 A. C. On red shale, from Wethersfield, Conn.

Original Description:—(from Hitchcock) "Hind and fore feet nearly but probably not exactly equal. Toes three, directed forward.

"Divarication of the lateral toes, nearly 90°; of the inner and middle toe, 50°; of the middle and outer toe, 40°. Length of the middle toe, reckoning from the point where the toes meet, 1 inch [25 mm.]; of the inner toe, 0.6 inch [15 mm.]; of the outer toe, 0.7 inch [17 mm.]; of the foot ***** 1.7 inch [27 mm.]; of the step [pace], 3.2 inches [80 mm.]; of the middle toe beyond the others, 0.5 inch

[12 mm.]. Distance between the tips of the lateral toes, 1.2 inch [30 mm.]. *** Angle between the axis of the foot and the median line, sometimes 15°. *** Width of the trackway, 2 inches [50 mm.]."

Discussion:—These dimensions correspond approximately with those of *Argoides minimus* which is therefore judged to be synonymous with *Plesiornis æqualipes*, the quadrupedal character of which is disproven. *Argoides minimus* has priority and is the accepted name.

(OMIT) *Plesiornis mirabilis* E. Hitchcock

E. Hitchcock 1865, p. 35, pl. 20.

Anchisauripus tuberosus Lull 1904A, p. 522; 1915, p. 188.

Holotype:—Cat. No. 51/16 A. C. from the Lily Pond, Gill, Mass.

Original Description: (from Hitchcock) "*Hind Foot*.—Divarication of the lateral toes, 35° to 40°. Length of the foot 6 to 6, 5/10 inches [153 to 162 mm.]. Width of the foot, 3 1/2 to 4 inches [88 to 100 mm.]. Length of the step as measured by the hind foot, 12 1/2 inches [318 mm.]. Claws distinct, but not the phalangeal impressions.

"*Fore Foot*.—Divarication of the lateral toes, between 80° and 90°. Length of the foot, 3 1/2 inches [88 mm.]. Width of the foot, 3 inches [75 mm.]. Length of the step as measured by the fore foot, 12 to 14 inches [304 to 354 mm.]. Claws indistinct. Hind and fore feet sometimes in contact, sometimes almost three inches [75 mm.] apart, but nearly abreast. Several very distinct grooves making a train 3 1/2 inches [88 mm.] wide, following the line of the tracks, varying in width from a mere line up to half an inch [12 mm.], not exactly parallel."

One of these grooves for about 6 inches strongly resembles a feather but may be compared with the mark made by the end of a stick drawn through the mud, which would form small oblique parallel ridges on each side of the groove.

Discussion:—This form has been identified by Lull as equivalent to *Anchisauripus tuberosus*, the similarity being especially marked in the hind foot.

(OMIT) *Plesiornis giganteus* C. H. Hitchcock

C. H. Hitchcock 1889, pp. 118, 122, 126.

Type Specimen:—Number not indicated. Part of a collection made in 1878 at Wethersfield Cove, Conn., and preserved in the Mount Holyoke Museum until its destruction by fire.

The collection is described as containing thirty-five species of Ichnozoa, eight of them being new to science. Among the latter are mentioned *Plesiornis giganteus* and *Plesiornis* new species to which no name or description is given.

Specific Description.—(after C. H. Hitchcock) "*Plesiornis giganteus* is a quadruped with trifold feet comparable with *Brontozoum* [*Anchisauripus*] *minusculum* in size, and related to a large *Iguanodon* from England. * * * The hind and front feet are nearly alike."

Discussion.—As no dimensions or other details are given and no living person has studied the original specimen, one can add nothing to Hitchcock's description except to dispute the quadrupedal character of the creature, (equally true of *Iguanodon*) and refer the species to *Anchisauripus minusculus* which of course has priority.

Plesiornis n. sp. is a nomen nudum.

(OMIT) *Plesiornis quadrupes* E. Hitchcock

Ornithoidichnites fulcoides E. Hitchcock, 1843, p. 258, pl. 11, fig. 10.

Æthyopus minor E. Hitchcock 1848, p. 179, pl. 4, figs. 2, 3.

E. Hitchcock, 1858, p. 102, pl. 16, fig. 7; pl. 35, figs. 1, 2; pl. 45, fig. 5.

Anomæpus intermedius, *Æthyopus minor* Lull 1915, p. 210.

Type Specimens.—Cat. Nos. 19/18 Turners Falls, 37/28, 37/29 A. C. Lily Pond, Gill, Mass.

Specific Characters.—(from Hitchcock). Manus: Length of digit II, 68 mm.; III, 90 mm.; IV, 68 mm.; of the hand, 100 mm.; between lateral tips, 75 mm. Divarication of digits II and III, 35°; of III and IV, 30°; of the lateral digits II and IV, 66°.

Pes: Length of digit II, 53 mm.; of III, 63 mm.; of IV, 63 mm. Projection of digit III beyond the others, 35 mm.

Length of foot, 96 mm.; between lateral tips, 88 mm.

Divarication of digits II and III, 40°; of III and IV, 30°; of the lateral digits II and IV, 70°. Length of pace, 116 to 153 mm. Width of trackway, 190 mm.

Angulation of both manus and pes, 5° inward. Fore foot the larger, generally a little in advance of the hind one, sometimes on one side, and not infrequently the two interfere.

Synonymy.—The dimensions of *Plesiornis minor* as given by Hitchcock 1848 agree fairly closely with those just quoted, sometimes lying between those of the so-called manus and the pes. The same is true of *Æthyopus minor* and of *Anomæpus intermedius*, the last named having priority.

Family ANCHISAURIPODIDÆ

Lull 1904A, p. 486; 1915, p. 180.

Family Characters.—Bipedal, tetradactyl; hallux, when impressed, rotated to the rear, well marked phalangeal pads; anterior claws acuminate but not strongly raptorial. No caudal impression.

↓
might be a small, rotator-like

Genus *Anchisauripus* Lull

Eubrontes (in part) E. Hitchcock 1845, p. 23.

Brontozoum (in part) E. Hitchcock 1847, p. 50.

Lull 1904A, p. 486; 1915, p. 181.

Generic Characters.—Bipedal, tetradactyl, hallux rotated to the rear so as to lie in line with digit IV. Hallux apparently arising above the level of the other digits so that only the imprint of the claw is ever made and that rarely.

Foot compact with little divarication of digits; phalangeal pads well developed, claws acuminate. No caudal impression.

Limbs of moderate length; that of the pace varying with the gait from moderate to extreme.

These tracks were apparently made by small dinosaurs, related to *Yaleosaurus* (*Anchisaurus*), and were strictly bipedal, for no trace of a manus imprint, which would be unmistakable because of the curved, grasping claws seen in the skeleton, has ever been found, although the pes imprints are very numerous.

The species included under this genus are the genotype, *Anchisauripus sillimani* (= *dananus*) (E. Hitchcock), *A. hitchcocki* Lull, *A. tuberosus* (= *validus*) (E. Hitchcock), *A. exsertus* (E. Hitchcock), *A. minusculus* (E. Hitchcock), and *A. parallelus* (E. Hitchcock) (= *Grallator parallelus* E. Hitchcock).

Discussion.—The species now assigned to the genus *Anchisauripus* seem to fall naturally into two groups, one containing *A. minusculus* only, which is of greater size and with other characteristics visible to the observer, but difficult to define. It is relatively rare and is confined to the uppermost Newark strata. The others are less akin, for there are occasional gradational footprints which bridge the dimensional gaps between the species and which are with difficulty and doubtfully assigned to one or the other. For the most part, however, the measurements of the tracks assigned to each species cluster around a mean. Not only do the dimensions as a whole vary but those of the relative lengths of the several digits in one form vary from those of another. Even the obverse and reverse of a single track, when they are counterparts, or of the same foot in successive steps, show these variations.

That the makers of these tracks were all dinosaurian is obvious and that they belong to the Theropoda is also without question; but an actual correlation of a known skeletal form with a given track includes a large element of doubt. So many factors—attitude, gait, the character of the sediment, and the subsequent distortion or mutilation of the specimen—enter into the problem, that unquestionable identity is impossible.

With the exception of *A. minusculus* the species of *Anchisauripus* show a complete range in space in the valley and also in time, for they

occur in the lower (anterior) shales, the upper (posterior) shales and in the greatest abundance in the upper (Portland) series of shales and sandstones.

The problems of sex and age variation are difficult if not impossible to evaluate, especially the former, for factual evidence is entirely lacking or unrecognizable. The age variation may be dependent on seasonal migrations to the valley from an, as yet undiscovered habitat. This would account, perhaps, for the separation of footprint-bearing strata by a considerable mass of barren rock before another productive layer is found.

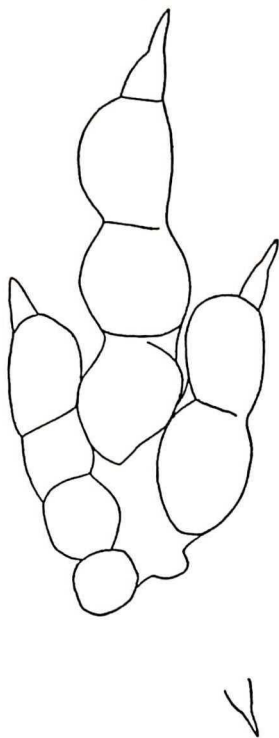


FIGURE 37.

Anchisauripus sillimani
(Hitchcock), modified
after Lull, from Cat. No.
36/19 A. C. one-half
natural size.

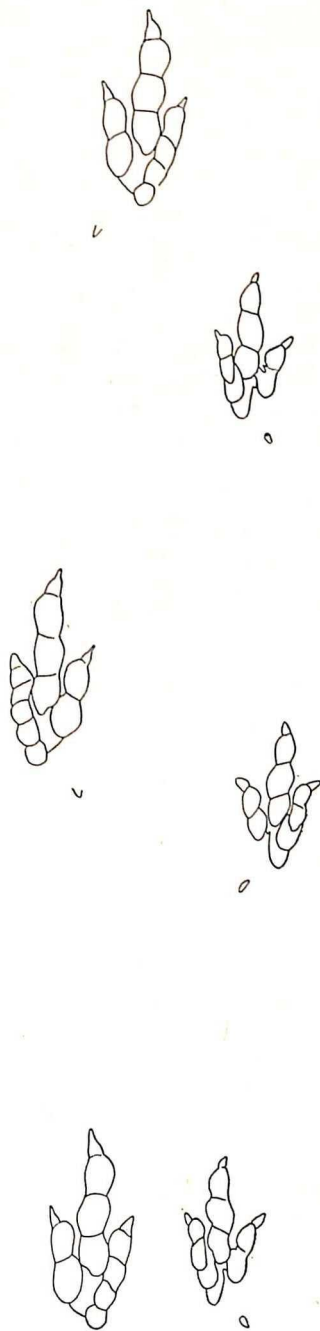


FIGURE 38.

Anchisauripus trackway, original,
one-sixth natural size. The larger
trail is that of *A. sillimani*, the
smaller, *A. hitchcocki*.

The interval represented by this barren rock would allow time for an age variation which many have interpreted as specific distinction.

Anchisauripus sillimani (E. Hitchcock)

Ornithoidichnites sillimani E. Hitchcock 1843, p. 256, pl. 11, fig. 2.

Eubrontes dananus E. Hitchcock 1845, p. 23. New species name in Synopsis without description or reason for the replacement of the name *sillimani*.

Brontozoum sillimani E. Hitchcock 1847, p. 49; 1848, p. 171, pl. 3, fig. 2; 1858, p. 68, pl. 12, fig. 3; pl. 3, figs. 4-5; pl. 43, fig. 6 (in part).

Anchisauripus dananus Lull, 1904A, p. 288, fig. 4.

Lull 1915, p. 181, fig. 38.

Holotype.—Cat. No. 9/14 A. C. from a quarry about two miles west of the city of Middletown, Conn. Served as a paving stone in the city of Middletown for about 60 years. It was then taken up and the footprints in high relief were found on the lower surface of the stone. It is considered the gem of the collection at Amherst.

Specific Characters.—Pes: Length of digit I, 50 mm.; of II, 77 mm.; of III, 115 mm.; of IV, 88 mm. Length of foot, 153 mm.; between the lateral tips, 67 mm.; projection of digit III beyond the others, 50 to 64 mm. Divarication of digits I and II, 139°; of II and III, 10°; of III and IV, 18°; of the lateral digits, II and V, 29°.

Length of pace, from 300 to 560 mm., varying with the gait. Width of trackway, 115 mm. Pes angulation, 0°; pace angulation, 165°. Distance of heel from midline of trackway, 0 to 25 mm. Ratio of foot to average pace, as 1 to 2.81.

Localities.—This species is found in nearly all the upper (Portland) horizon localities, such as the Horse Race, Lily Pond, Ferry above and at Turners Falls, Field's orchard in Gill, Smith's Ferry, South Hadley, Moody's Corner, Stream near Pliny Moody's and Chicopee Falls, Mass.; Wethersfield, Portland, Middletown, Middlefield (upper shales), Conn.; and Whitehall, N. J.

Geological Distribution.—Posterior (upper) shales and the Portland series.

Anchisauripus hitchcocki Lull

Anchisauripus sillimani (in part)

Lull 1904A, p. 488, fig. 5; 1915, p. 182, fig. 39.

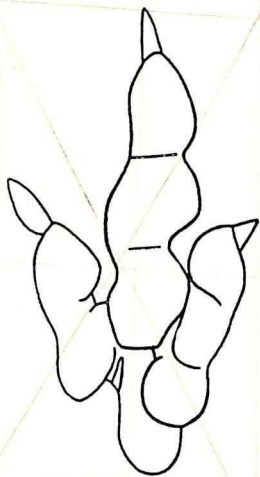


FIGURE 39.

Anchisauripus hitchcocki
Lull, after Lull, from the
type, Cat. No. 56/1 A. C.
one-half natural size.

Holotype.—Cat. No. 56/1 A. C. from the Lily Pond, Gill, Mass., associated with *A. minusculus*. A photograph of this slab is shown in Hitchcock 1865, pl. 16, fig. 1.

Specific Characters.—Pes: Length of digit II, 60 mm.; of III, 88 mm.; of IV, 75 mm.; of the foot exclusive of the hallux, 119 mm.; including the hallux, 140 mm. Distance between lateral tips, 47 mm. Divarication of digits I and II, 138°; of II and III, 19°; of III and IV, 14°; of the lateral digits, II and IV, 33°. Extension of digit III beyond the lateral toes, 47 mm.

Length of pace, 360 to 500 mm. Width of trackway estimated at 100 mm.

Pes angulation, 0°. Pace angulation, about 165°.

Ratio of foot to average pace, as 1 to 3.6.

Localities.—Lily Pond, Horse Race, Montague, Ferry, Gill, Turners Falls, Mass. Also on the Middletown slab, Cat. No. 9/14 A. C., with *A. sillimani*, Conn.

Stratigraphic Distribution.—Upper (Portland) series.

Discussion.—*Anchisauripus sillimani* and *hitchcocki* show little distinction other than size, but with the measurements of a number of specimens of each, species cluster around a mean average, and there are transitional specimens which bridge the gap between the two. May they not be age variations of the species *sillimani*, for they are found in association on the Middletown slab, Cat. No. 9/14 A. C.?

Summing up without question mark.

Anchisauripus tuberosus
(E. Hitchcock)

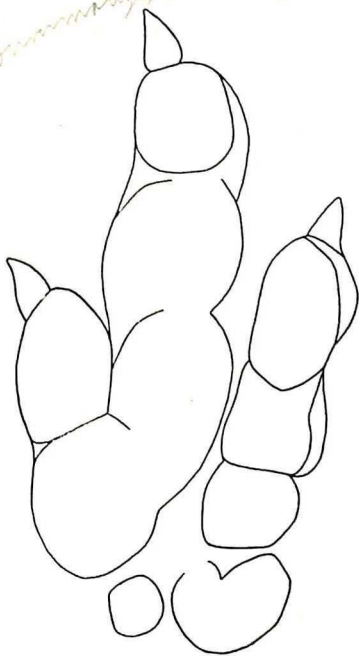
Ornithichnites tuberosus E. Hitchcock 1836, p. 318, figs. 2, 5 (in part).

Ornithoidichnites tuberosus E. Hitchcock 1841, p. 486, pl. 37, fig. 20 (in part).

Eubrontes tuberosus E. Hitchcock 1845, p. 23.

Brontozoum validum E. Hitchcock 1858, p. 67, pl. 12; pls. 38-43; pl. 57, fig. 3.

Lull 1904A, p. 488, fig. 6; 1915, p. 182, fig. 40.



✓

FIGURE 40.

Anchisauripus tuberosus (Hitchcock)
after Lull, one-half natural size.

Holotype.—Cat. No. 31/73, A. C., on red shale from Turners Falls, Mass.

Specific Characters.—Pes: Length of digit II, 86 mm.; of III, 128 mm.; of IV, 120 mm.; of the foot, 168 mm.; between lateral tips, 90 mm.; projection of digit III beyond the lateral ones, 55 mm. Divarication of digits II and III, 14° ; of III and IV, 13° ; of the lateral digits, II and IV, 27° . Pes angulation, 0° to 10° .

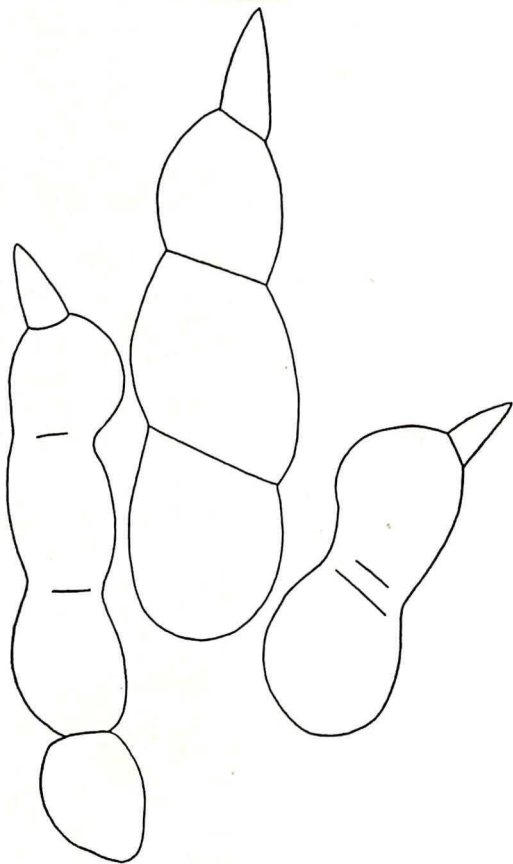


FIGURE 41.

Anchisauripus exsertus (Hitchcock) modified after Lull,
from Cat. No. 54/1 A. C. one-half natural size.

Length of pace, 440 mm. Width of trackway 203 mm.

Ratio of foot to pace, as 1 to 2.62.

Localities.—Horse Race, Lily Pond, Turners Falls, Field's orchard in Gill, north side Mount Holyoke (lower shales), east side Mount Tom, Smith's Ferry, South Hadley, Moody's corner, Mass.; and Wethersfield and Portland, Conn.

Discussion.—Comparative measurements of twenty-two tracks exclusive of the type are as follows: Length of digit II, 77 to 107 mm.; average, 95 mm.; of III, 120 to 195 mm., average, 136.7 mm.; of IV, 90 to 143 mm.; average, 112 mm.; of the foot, 164 to 208 mm.; average, 183.5 mm.; between the lateral tips, 84 to 149 mm.; average, 106 mm.

Divarications of 20 specimens: II to III, 9° to 29° , average, 18.6° ; of III and IV, 10° to 30° , average 25.2° ; of II and IV, 20° to 55° , average, 30.2° .

Specimens other than the type prove somewhat larger and yet are clearly referable to the species.

"A very numerous and variable type, in size between *Anchisauripus sillimani* and *A. exsertus*, with no marked peculiarities other than size to distinguish it from either" (Lull). The type specimen unfortunately has been trimmed in such a way as to destroy the hallux impression if it existed, the presence of the hallux print being unsuspected until demonstrated by Lull in 1904.

Anchisauripus exsertus (E. Hitchcock)

Brontozoum exsertum E. Hitchcock, 1858, p. 67, pl. XII, fig. 1.

Lull 1904A, p. 480, fig. 7; 1915, p. 184, fig. 41.

Holotype.—Cat. No. 16/6 A. C., on gray micaceous sandstone, from Smith's Ferry, Mass.

Plesiotype.—Cat. No. 54/1 A. C., on red shale from Field's orchard, Gill (figured and described by Lull).

Specific Characters (from the plesiotype).—Length of digit I, 75 mm.; of II, 117 mm.; of III, 161 mm.; of IV, 154 mm.; foot exclusive of hallux, 226 mm.; including hallux, 265 mm.; between lateral tips, 116 mm. Projection of digit III beyond the others, 78 mm. Divarication of digits I and II, 75° ; II and III, 18° to 20° ; of III and IV, 15° ; of II and IV, 34° .

Length of pace, 922 to 985 mm. Width of trackway, 152 mm. Ratio of foot to average pace, as 1 to 4.21.

Pes angulation, 0° to 5° outward.

Localities.—Upper (posterior) shales: Mount Tom East, Mass.; Middlefield and North Branford, Conn. (sub-species *branfordi* Thorpe). Upper series: Turners Falls region, Smith's Ferry, Moody's Corner, Chicopee Falls, Mass.; Wethersfield and Portland, Conn.

Discussion.—This species comes nearest to *Anchisauripus tuberosus*; in fact, in the catalogue of the Amherst collection published in the

A. tuberosus
only, not *A. exsertus*
only, not *A. exsertus*

Supplement, 1865, the slab No. 54/1, is described as one "with numerous impressions of *B. validum* [*A. tuberosus*]", one of which was the basis of the above description and figure by Lull. The principal distinctions between the two species seems to lie in dimensions only, *exsertus* being the larger, for the character which gives the name '*exsertus*', that of the unusual projection of the middle toe beyond the lateral ones, is not always evident.

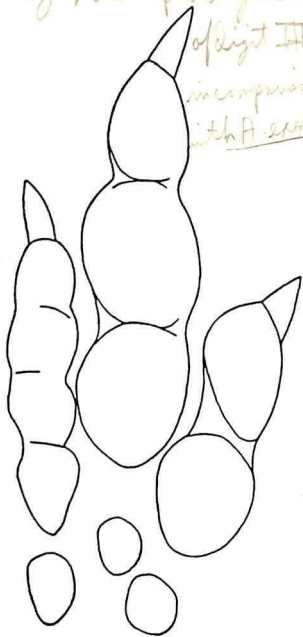
Anchisauripus exsertus branfordi Thorpe 1929

Thorpe, Am. Jour. Sci. (5) XVIII, pp. 293-4, fig. 9.

Holotype.—Cat. No. 360 Y. P. M., on tough gray sandstone, Sugar Loaf tunnel, North Branford, Conn. Upper (posterior) shales.

Original Description.—"This print [of right pes in high relief] is about one-eighth larger than the plesiotype of *A. exsertus* (E. Hitchcock), Cat. No. 54/1 Amherst collection. The most marked characteristic is the unusual prolongation of the third digit beyond the tips of digits II and IV, this being 50 percent longer than in the plesiotype. The foot is more closely appressed, and the terminal phalanx of digit IV is turned out quite sharply, fully 50 percent from digit III. Digit II seems to be much shorter, but this may be due to not impressing itself to its full extent. The hallux impression is lacking."

characterized by extreme prolongation of digit III, impression with *A. exsertus*.



Anchisauripus parallelus (E. Hitchcock)

E. Hitchcock, 1865, p. 7.

Grallator parallelus. E. Hitchcock 1865, p. 7, pl. 5, fig. 1.

Lull, 1904A, pp. 490-491, fig. 9; 1915, p. 183, fig. 43.

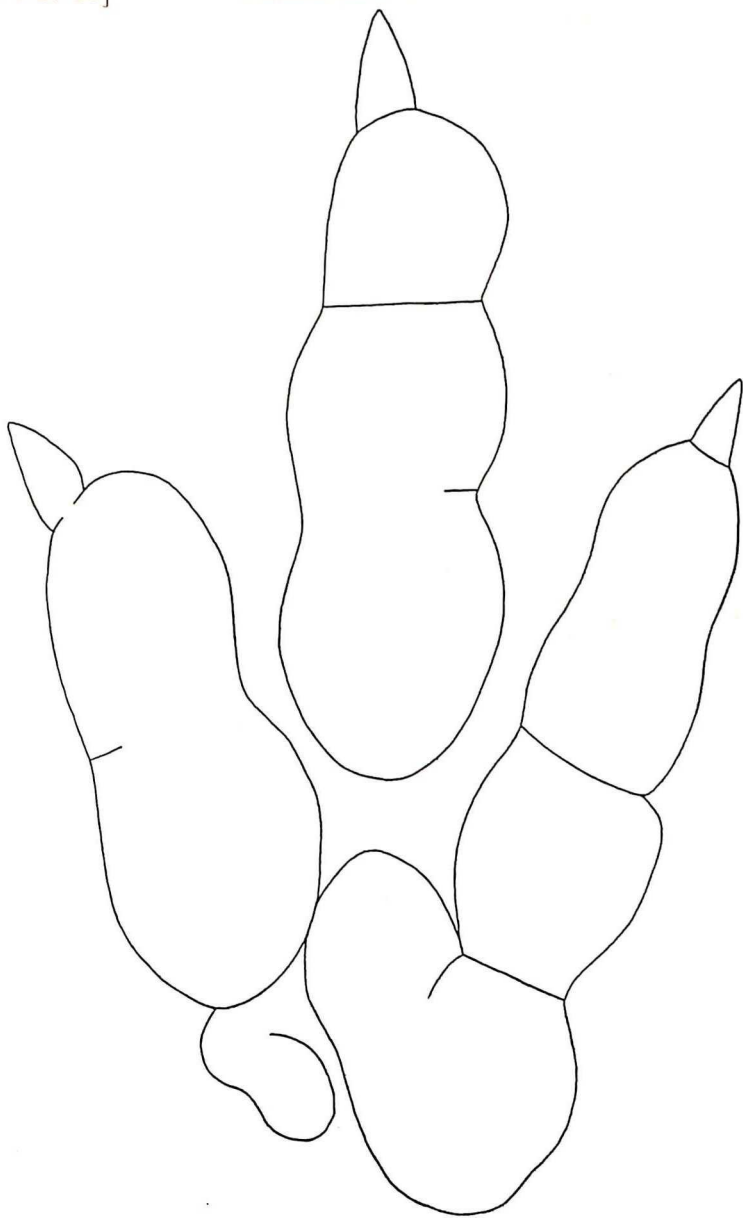
Thorpe, 1929, p. 294.

Holotype.—Cat. No. 54/8, A. C., on red sandstone from Field's orchard, Gill, Mass., in association with *Anchisauripus tuberosus*, *A. sillimani*, and *Grallator cursorius*.

Specific Characters.—Pes: Length of digit I, 67 mm.; of II, 79 mm.; of III, 118 mm.; of IV, 90 mm. Length of foot, 178 mm.; between lateral tips, 75 mm. Projection of digit III beyond the others, 55 mm. Divarication of digits II and III, 12°; of III and IV, 6.5°; of the lateral toes, II and IV, 17°.

FIGURE 42.

Anchisauripus parallelus (Hitchcock) after Lull, from the type, Cat. No. 54/8 A. C. one-half natural size.



V

FIGURE 43.
Anchisauripus minusculus (Hitchcock) modified after Lull, from the
type, Cat. No. 16/1 A. C. one-half natural size.

Length of the stride, 1,015 mm.; of the pace, 260 mm. *Suppose first.*

Width of trackway unrecorded. Pes angulation, 0° .

Ratio of foot to pace, as 1 to 1.46; of foot to stride (maximum), as 1 to 5.7.

Localities.—Horse Race, Lily Pond, Gill, Turners Falls, South Hadley, Moody's Corner, Mass.; North Branford, Conn. Upper (posterior) shales; and Whitehall, N. J.

Geological Distribution.—Upper (Portland) series.

Discussion.—This form is removed from *Grallator* because of the shortness of step and relatively wide trackway and also by the presence of the hallux impression. *Anchisauripus parallelus* approaches *A. silli-* extreme narrowness of digit IV, and in the three distinctive sole pads which are, however, a somewhat variable feature in the track.

This is not the *Brontozoum parallelum* of Hitchcock 1847 which represents a smaller animal and which Hitchcock does not mention after 1848. What assignment is made of the specimens of *B. parallelum* is unknown to the present writer.

Anchisauripus minusculus (E. Hitchcock)

Brontozoum minusculum E. Hitchcock 1858, p. 65, pl. 11, fig. 1; pl. 40, fig. 2; pl. 41, fig. 1; pl. 42, fig. 3; pl. 57, fig. 2.

Lull, 1904A, p. 490, fig. 8; 1915, p. 185, fig. 42.

Holotype.—Cat. No. 16/1 A. C., on fine red shale from the Lily Pond, Gill, Mass.

Specific Characters.—Pes: Length of digit I, 100 mm.; of II, 158 mm.; of III, 192 mm.; of IV, 223 mm. (164 without heel pad). Length of foot exclusive of hallux, 310 mm.; with hallux, 374 mm.; between lateral tips, 190 mm. Projection of digit III beyond the other toes, 98 mm. Divarication of digits II and III, 17° ; of III and IV, 18° ; of the lateral digits, II and IV, 34° .

Length of pace, 382 to 655 mm.; of stride, 1,000 mm.

Width of trackway, 320 mm.

Pes angulation, 0° to 20° inward.

Ratio of foot to average pace, as 1 to 1.672.

Localities.—Lily Pond, Horse Race, Gill, Turners Falls, Smith's Ferry, South Hadley, Moody's Corner, Mass.; Wethersfield Cove, Conn.; and Whitehall, N. J.

Geological Distribution.—Upper (Portland) series.

Discussion.—*Anchisauripus minusculus* is the largest species of the genus and is an elegant track larger than some *Eubrontes* species, but distinguished from them by its compact form and the presence of the imprint of the hallux claw. It is the most sharply defined species of the genus, for its measurements do not merge with those of any other form. The track is that of a carnivorous dinosaur, of the proportions, but twice the size of *Yaleosaurus* (*Anchisaurus*) *corurus*; about fourteen feet in length.

Just my "largest species of the genus."

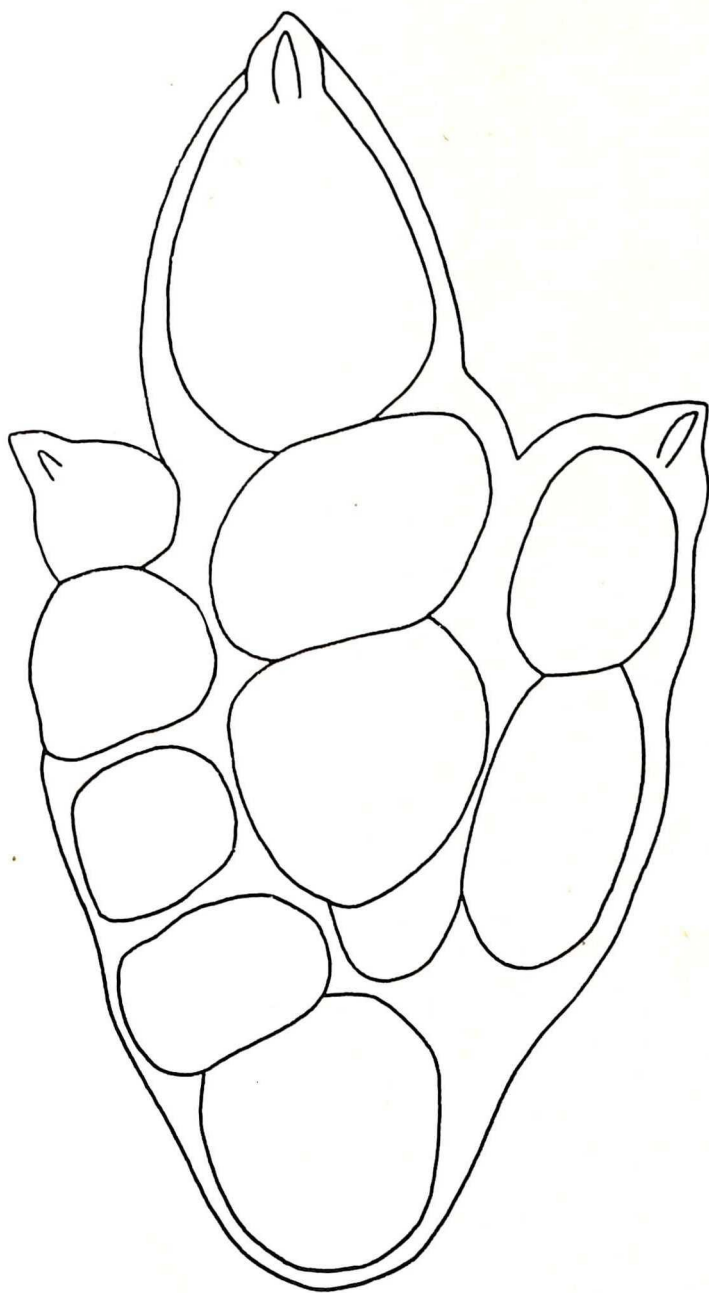


FIGURE 44.
Otouphepus magnificus Cushman modified after Cushman, from the
type, Cat. No. 12,857, Boston Soc. Nat. Hist., natural size.

Genus *Otouphepus* Cushman

Cushman 1904, Amer. Geol., vol. 33, p. 154.

Lull, 1915, p. 187.

Generic Characters.—Digitigrade, tridactyl, pachydactylous, compact tracks; phalangeal pads clearly impressed, claws small, acuminate. Presence of a web-like expansion between the digits and around them doubtful. Rare.

But two species have been described, *Otouphepus magnificus* Cushman, the genotype, and *O. minor* Lull.

Cushman's generic definition is as follows:

"Footprint tridactylous, digits decidedly pachydactylous, connected by a web, incised between the digits. Impressions of the joints of the digits very indistinctly shown. Digits terminated by fairly sharp claws, the expansions however extending beyond as the foot is placed flat upon its under surface....."

"As the foot is placed flat, the web on the inner margin is spread out and the scallops distinctly seen. They are very similar to certain of the reptiles of the present time in this respect.

"Although such a footprint cannot be placed in any of the present genera as they are defined by Hitchcock, it is very probable that it represents an animal of the type of *Eubrontes dananus* E. Hitch. [*Brontozoum sillimanium* E. Hitch.] [*Anchisauripus sillimani*]. However, in perfect specimens of that species in the same sort of matrix where a distinct outline is shown, there are no such traces of a web. There are slight expansions, but they are of a different nature. The measurements and number of joints are very similar; but so they are in *Plesiornis mirabilis* of Hitchcock [probably identical with *Anchisauripus tuberosus*] which is nearer *A. dananus* [*A. sillimani*] than the present form under discussion. The joints of the phalanges, the turning aside of the claws, and the general skeletal shape would put the animal which made the present track in group II. of Hitchcock, p. 63—although they were doubtless dinosaurs and not 'thick-toed birds,' as he terms them."

Discussion.—Cushman stresses the presence of a web connecting the digits but incised between them and surrounding the entire foot even beyond the claw impressions. This so called web in the type specimen is represented by a darker area on the surface of the stone but has no thickness or other indication of an actual web, and may be due in part simply to a slight wave of mud displaced by the animal's weight.

Otouphepus magnificus Cushman

Cushman 1904, p. 154, pl. VI.

Lull 1915, p. 190, fig. 44 (after Cushman).

Holotype.—Cat. No. 12,857, Boston Soc. Nat. Hist., from Gill. Massachusetts. A single isolated print of the left pes.

Specific Characters.—Pes: those of the genus. Dimensions: Length

of digit II, 83 mm.; of III, 114 mm.; of IV, 85 mm. With heel pad, 114 mm. Of the foot, 163 mm.; between lateral tips, 86 mm. Projection of digit III beyond the other toes, 55 mm. Divarication of digits II and III, 22° ; of III and IV, 17° ; of the lateral digits, II and IV, 43° .

No track pattern obtainable.

Locality.—Gill, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion.—The footprint is compact, with the digits scarcely separated from one another, except for the phalangeal pads, the fourth digit being small and very little offset from the third. The so-called web is indicated merely by a black coloring of the rock surface and is of doubtful origin.

Compare Cushman's figure with that of Lull from the same specimen (fig. 44).

The several specimens in the Y. P. M. collection give no confirmatory evidence of the presence of a web, but one, Cat. No. 3386. Y. P. M., shows a decided mud wave displaced by the creature's weight as in *Otozoum*.

Otouphepus minor Lull

Lull, 1914, p. 190, fig. 45.

Holotype.—Cat. No. 2059, Y. P. M., from Gill, Mass., a beautiful single footprint.

Specific Characters.—Pes: Small, compact, tridactyl, digitigrade, with well defined phalangeal pads and small, acuminate claws.

Dimensions. Length of digit II, 48 mm.; of III, 57 mm.; of IV, 51 mm.; of foot, 88 mm. Projection of digit III beyond the lateral toes, 38 mm. Between lateral tips, 37 mm. Divarication of digits II and III, 13° ; of III and IV, 22° ; of the lateral digits, II and IV, 32° .

As this again is an isolated footprint, no further trackway pattern is available.

Locality.—Gill, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion.—In this specimen, the phalangeal pads, while their outlines can be seen, show little prominence



FIGURE 45.

Otouphepus minor Lull, modified after Lull, from the type, Cat. No. 2059 Y. P. M. natural size.



of the individual pads but the displacement of the mud shows especially on either side of the deeply impressed middle digit, the surface of the shale being thrown into numerous minute parallel wrinkles. The web-like wave embraces the claw, as in *O. magnificus*.

The principal diagnostic feature is that of size, another being the lesser projection of digit IV.

In size this species comes nearest *Gratator cursorius*.

Infraorder Carnosauria

Group II. Large, digitigrade, functionally tridactyl. No manus imprint. Hallux sometimes impressing.

a. Tridactyl—no hallux imprint or tail trace.

Eubrontes

b. Tetradactyl, hallux imprint, tail trace.

Gigandipus

Hyphepus

Family Eubrontidae

Family characters.—those of the genus *Eubrontes*.

Genus *Eubrontes* E. Hitchcock

E. Hitchcock 1845, p. 23.

Brontozoum E. Hitchcock 1847, p. 50; 1848, p. 169; 1858, p. 63.

Lull 1904A, p. 510; 1915, p. 195.

Generic Characters.—The footprints to which the name *Eubrontes* has been given are among the largest and most abundant of those of the Connecticut Triassic. They represent relatively huge, ponderous, bipedal forms, definitely dinosaurian and probably Theropodous although not perhaps strictly carnivorous in their habits for they lack the trenchant, raptorial type of claws generally associated with beasts of prey.

Large, bipedal forms, with claws acuminate to blunted. Digits broad, with well



FIGURE 46.
Eubrontes trackway,
original, one-sixteenth
natural size.

*Some few characters
of the family.*

defined phalangeal pads. No indication of a hallux claw with one possible exception, or of a dragging tail. Manus never impressing.

Discussion.—*Eubrontes* differs from *Anchisauripus* in its generally greater size and robustness, usually blunter claws, and in the absence of a hallux imprint. It is distinguished from *Gigandipus* by the absence of a hallux and a tail trace, which are present in the latter, although specimens of the two genera are occasionally of approximately equal size, and certain specimens, pertaining to the one or the other, may be confused. Five species are now included in the genus *Eubrontes*, of which *Eubrontes giganteus* is the genotype.

Eubrontes giganteus

E. Hitchcock

E. Hitchcock 1845,
p. 23.

Ornithichmites gi-
ganteus Hitchcock
1836, p. 317, figs. 1, 21.

Ornithoidichnites
giganteus Hitchcock
1841, p. 484, pl. 36,
fig. 18.

Brontozoum gigan-
teum Hitchcock 1847, p.
57; 1848, p. 169, pl. 1,
fig. 1; 1858, p. 64, pl. 33,
figs. 1-3; pl. 41, fig. 1;
pl. 53, fig. 7; pl. 57, fig. 1.

C. H. Hitchcock in
E. Hitchcock, 1865, p.
23, pl. 10, fig. 1.

Lull 1904A, p. 510,
fig. 31; 1915, p. 195,
fig. 48.

Holotype.—Cat. No.
45/8 A. C. Locality un-
recorded. Figured speci-
men Cat. No. 45/1 A. C.

Specific Characters:

—Pes: Length of digit II,
200 mm.; of III, 260 mm.; of IV, 285 mm.; of digit III beyond the
lateral ones, 139 mm. Length of the foot, 370 mm.; between the lateral
claws, 225 mm. (dimensions from No. 45/1 A. C.) Divarication of digits
II and III, 18°; III and IV, 20°; of the lateral digits, II and IV, 40°.
Length of pace, 1,090 to 1,170 mm.; of the stride, 1,220 to 1,520 mm.
Width of the trackway, 452 mm.

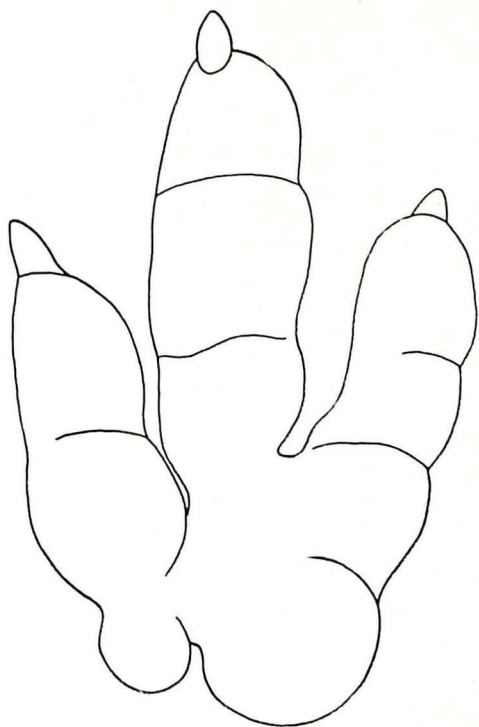


FIGURE 47.

Eubrontes giganteus modified after Lull, from
Cat. No. 45/1 A. C., one-fourth natural size.

Pes angulation, 0° to 10° ; interpes distance from center of heel, 0 to 2.54 mm. Ratio of foot to average pace, as 1 to 3.05.

Localities.—Horse Race, Lily Pond, Gill, Turners Falls, Mount Tom West (lower shales), Smith's Ferry, and Holyoke, Mass.; Wethersfield Cove, Wethersfield, Portland, and Middlefield (upper shales), Conn. and North Branford (upper shales) Conn.; and Whitehall, N. J.

Geological Distribution.—From the lower shales to the upper (Portland) series. The extreme range for dinosaurian tracks.

Discussion.—*Eubrontes giganteus* is the widest spread geographically ranging the entire length of the Connecticut valley and into New Jersey. It is one of the most conspicuous and earliest described forms and may be exceeded in size only by *E. approximatus*, *Gigandipus caudatus*, and possibly by *Otozoum moodii* and by the huge aberrant *Anticheiropus pilulatus*.

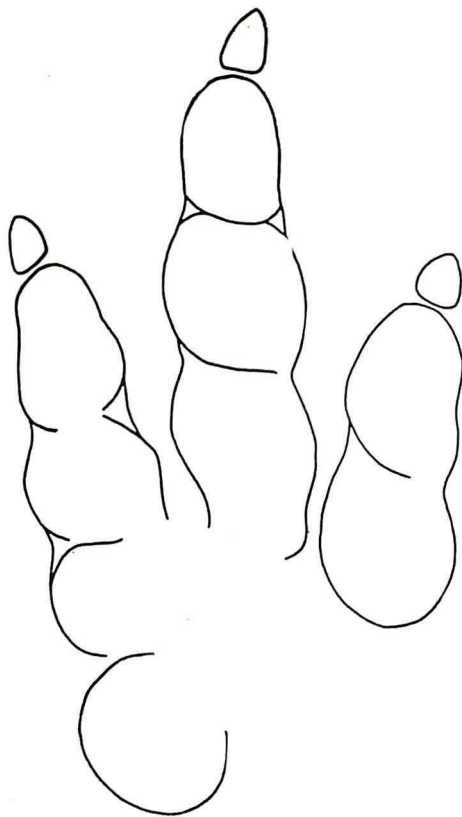


FIGURE 48.

Eubrontes approximatus (C. H. Hitchcock)
after Lull, from Cat. No. 32/51 A. C.
one-fourth natural size

Eubrontes approximatus (C. H. Hitchcock)

Brontozoum approximatum C. H. Hitchcock in E. Hitchcock 1865, p. 24, pl. 10, fig. 2. *Brontozoum giganteum* in part.

Lull 1904A, p. 510, fig. 32; 1915, p. 196, fig. 49.

Holotype.—Cat. No. 54/10, A. C., on gray shale from Turners Falls. Also 32/51 A. C., figured by Lull (Plesiotype).

Specific Characters.—*Pes*: (Of the two measurements, the first is from the type and the second from Cat. No. 33/51. A. C.) Length of digit II, 153-192 mm.; of III, 228-274 mm.; of IV, 295-308 mm. Projection of digit III beyond the lateral toes, 100-121 mm.; length of the foot, 383-408 mm.; between lateral claws, 190-220 mm. Divarication of digits II and III, 30° - 15° ; of III and IV, 24° to 13° ; of the lateral digits, II-IV, 50° - 22° .

Length of the step (?pace) 913 to 1,215 mm. (from No. 8/1 A. C.) (C. H. H.).

Ratio of foot to average step, as 1 to 3.86.

Pes angulation, 0° to 10° . Interpes measured from center of heel, 0 to 254 mm. Both these dimensions about the same as in *E. giganteus* (C. H. H.).

Localities:—Horse Race, Lily Pond, Gill, Ferry above Turners Falls, Mt. Tom in Northampton, Mass.; North Branford (upper shales), Conn.

Discussion:—The specimens now referred to this species in the Amherst catalogue were formerly considered *E. giganteus*. The main points of distinction, according to C. H. Hitchcock, are the slenderer digits and their greater divarication in *approximatus*. In Cat. No. 32/51, the divarication of the digits is much less than in either the type or a typical *giganteus*. However, the divarication is a very variable factor even in a succession of tracks of the same individual. The relative slenderness of the digits seems to be the only constant distinction between the two species and may be only of varietal value.

Eubrontes platypus Lull

Lull 1904A, p. 512, fig. 5;
1915, p. 199, fig. 51.

Amblonyx giganteus E.
Hitchcock, 1858, p. 71, pl. 13,
fig. 1; pl. 38, figs. 1, 2; pl. 42,
fig. 5.

The name *platypus* was substituted for *giganteus*, which is preoccupied within the genus.

Holotype:—Cat. No. 13/4 A. C., on red shale from Turners Falls, Mass.

Specific Characters:—Pes: Length of digit II, 153 mm.; of III, 190 mm.; of IV, 215 mm. Projection of digit III beyond the lateral toes, 80 mm. Length of the foot, 267 mm.; between lateral claws, 190 mm. Divarication of digits II and III, 12° ; of III and IV, 22° ; of the lateral digits, II and IV, 32° .

Length of pace, 1,135 mm. [813 Hitchcock]. Width of trackway, 304 mm.

Ratio of foot to pace, as 1 to 4.25, a very long limbed form.

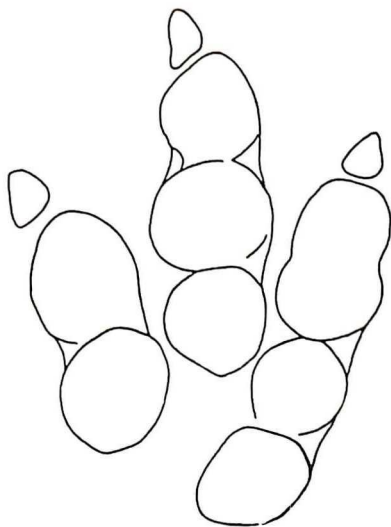


FIGURE 49.
Eubrontes platypus Lull, after Lull.
from the type Cat. No. 15/4 A. C.
one-fourth natural size.

Pes angulation, 0° .

Localities.—Turners Falls, Holyoke, Mass.; Middlefield, Conn.

Geological Distribution.—From the upper (posterior) shales to the upper (Portland) series.

Discussion.—The species *Amblonyx giganteus* was considered as doubtful by Hitchcock in 1865, p. 2, on the ground of "an apprehension that the rounded form of the claw on the tracks which gives the character of the genus, may originate from other causes than the rounded or winged character of the claw itself?"

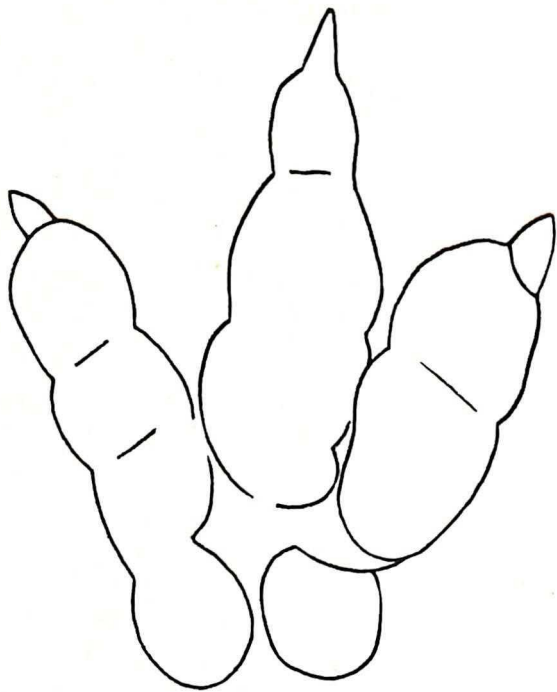


FIGURE 50.

Eubrontes divaricatus (Hitchcock) after Lull, from the type Cat. No. 58/1 A. C. one-fourth natural size.

***Eubrontes divaricatus* (E. Hitchcock)**

Brontozoum divaricatum E. Hitchcock, 1865, p. 7, pl. 4, fig. 1.

Brontozoum isodactylum (in part). E. Hitchcock, 1858, p. 69, pl. 12, fig. 3.

Lull 1904A, p. 512, fig. 23; 1915, p. 198, fig. 50.

Holotype.—Cat. No. 58/1 A. C., on hard shale. Locality unrecorded.

Specific Characters.—Pes: Length of digit II, 193 mm.; of III, 243 mm.; of IV, 262 mm. Extension of digit III, beyond the lateral toes,

95 mm. Length of the foot, 340 to 360 mm.; between lateral tips, 270 mm. Divarication of digits II and III, 20° ; of III and IV, 35° to 50° ; of the lateral digits, II and IV, 52° .

Length of the step, 1,040 to 1,190 mm.

Width of the trackway, 457 mm.

Ratio of average foot to average step, as 1 to 3.18.

Localities:—Horse Race, Lily Pond, Gill, Turners Falls, South Hadley, Mass.; Wethersfield, Conn. and Whitehall (Towaco), N. J.

Geological Distribution:—Upper (Portland) series of sandstones, etc.

Discussion:—For the most part, the specimens of *Brontozoum isodactylum* are now referred to *Anomæpus intermedius* with which it clearly corresponds. None of the specimen numbers in the Amherst collection has been assigned to the present species which throws further doubt upon even a partial identity.

In size, *E. divaricatus* approaches most nearly to *Anchisauripus minusculus*, especially in over-all length, but there the resemblance ceases, for *divaricatus* is readily distinguished by its greater robustness and especially by the greater divarication of the digits, particularly the fourth. It lacks the compact elegance of *A. minusculus* and there is no evidence of a hallux imprint.

Eubrontes tuberatus (E. Hitchcock)

Brontozoum tuberatum E. Hitchcock 1858, p. 66, pl. 11, fig. 2; pl. 52, fig. 7.

Anchisauripus tuberatus, Lull 1904A, p. 491, fig. 10.

Eubrontes tuberatus, Lull 1915, p. 199, fig. 52.

Holotype:—Cat. No. 27/17 A. C., on red shale, from the Lily Pond, Gill, Mass.

Specific Characters:—Pes: Length of digit II, 140 mm.; of III, 172 mm.; of IV, 170 mm.; projection of digit III beyond II and IV, 65 mm. Length of foot, 249 mm.; between lateral tips, 152 mm. Divarication of digits II and III, 17° ; of III and IV, 8° ; of the lateral digits, II and IV, 25° .

Length of pace, 788 mm. Width of trackway, 204 mm.



FIGURE 51.

Eubrontes tuberatus (Hitchcock)
after Lull, from the type
Cat. No. 27/17 A. C.,
one-fourth natural size.

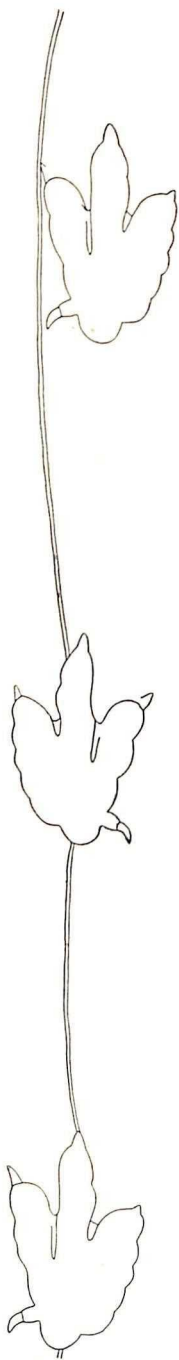


FIGURE 52.
Gigandipus trackway,
original, one-sixteenth
natural size.

Ratio of foot to pace, as 1 to 3.18.

Pes angulation, 0° - 10° .

Localities:—Field's orchard, Gill; Lily Pond, Gill, Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Eubrontes tuberatus* resembles *E. platypus* in general proportions, except that the divarication of the middle and outer toes is much less and the ratio of foot to pace also shows a relatively shorter length of limb.

E. tuberatus also resembles *Anchisauripus minusculus*. It differs therefrom in being smaller and in the much less divarication of the outer digits; the absence of a hallux claw imprint and in the more circular form of the phalangeal pads.

Family GIGANDIPODIDÆ

Family Characters.—Typically very large forms, hallux half rotated, impressing its entire length. Foot flatly digitigrade. Caudal trace present.

Genera: *Gigandipus* and the much smaller *Hyphepus*.

Genus *Gigandipus* E. Hitchcock

E. Hitchcock 1855, p. 415 (no description); 1856, p. 97.

Gigantitherium E. Hitchcock 1858, p. 93.

Lull 1904A, p. 492.; 1915, p. 191.

Generic Characters:—Huge, bipedal forms. Tetradactyl, hallux incumbent, half rotated. Foot flatly digitigrade. No manus imprint present. Caudal trace sinuous and continuous.

Discussion:—The most distinctive feature of the *Gigandipus* track is the small, curved hallux which impresses for its entire length and therefore arises lower on the foot than in *Anchisauripus*, in which only the tip of the claw touches, lies much further to the rear, and represents a more powerful grasping talon. *Gigandipus caudatus* resembles *Eubrontes giganteus* very closely

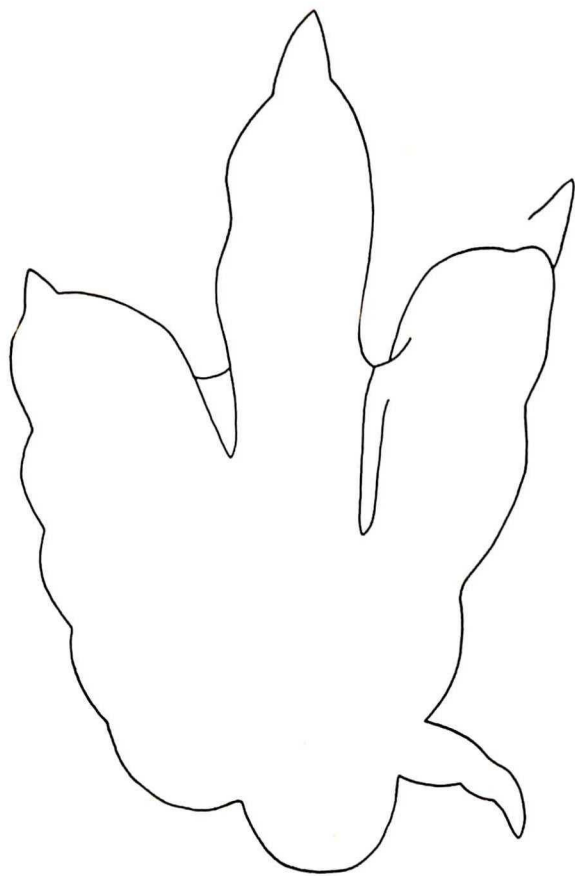


FIGURE 53.

Gigandipus caudatus Hitchcock, modified after Lull, from the types 9/9 and 9/10 A.C. one-fourth natural size.

in general form and dimensions and is doubtless sometimes confused with that species when the hallux and tail trace are not present in the specimen.

With the possible exception of the unique track of *Anticheiropus pilulatus* and that of *Otozoum moodii*, this genus includes the most majestic of Connecticut valley dinosaurs.

But one species of *Gigandipus* is now recognized, *G. caudatus*, the genotype. The second species, *Gigantitherium minus* E. Hitchcock, has now been removed to the genus *Apatichnus*.

***Gigandipus caudatus* E. Hitchcock**

E. Hitchcock 1855, p. 417 (named but not described); 1856, p. 97, text figure.

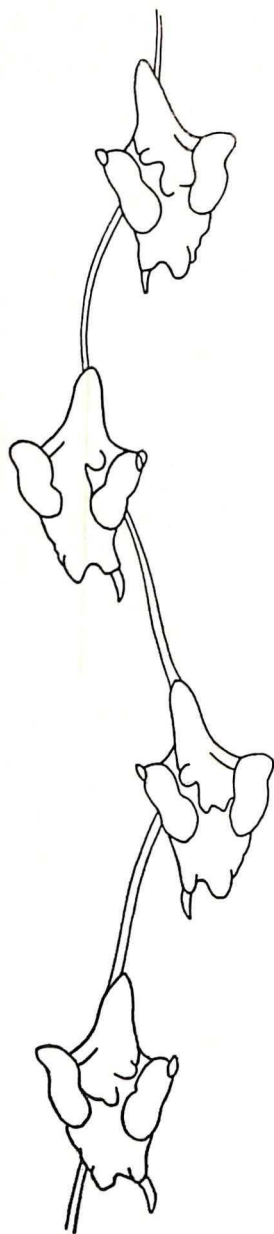


FIGURE 54.

Hyphepus trackway, original,
one-fourth natural size.

impressing; phalangeal pads obscurely defined. Three anterior digits connected by a web-like membrane, hence the generic name (a web-footed animal). Tail trace present.

Gigantitherium caudatum E. Hitchcock 1858, p. 93, pl. 16, figs. 1-2, pl. 44, fig. 4.

Lull 1904A, p. 492, fig. 11; 1904B, fig. on p. 141; 1915, p. 192, fig. 46.

Cotypes.—Cat. Nos. 9/9, 9/10, A. C., on reddish shale from the Lily Pond, Gill, Mass.

Length of digit I, 80 mm.; of II, 215 mm.; of III, 275 mm.; of IV, 290 mm.; projection of digit III, beyond the others, 108 mm. Length of the foot, 445 mm.; between lateral tips, 285 mm. Divarication of digits I and II, 98°; of II and III, 22°; of III and IV, 30°; of the lateral toes, II and IV, 53°.

Length of the pace, 988 to 1,020 mm. Width of the trackway, 305 mm.

Ratio of foot to pace, as 1 to 2.29.

Pes angulation, about 0°. Tracks nearly in line. Tail trace sinuous and continuous, about 6 to 12 mm.; wide.

Localities.—Lily Pond, Gill, Turners Falls, Mass. Portland and North Branford, Conn.

Geological Distribution.—Upper shales, and upper (Portland) series of sandstones, etc.; upper (posterior) shales.

Discussion.—Comparing the relative proportions of the foot impressions of this species, 445 mm., and those of *Allosaurus*, 720 mm., would give to *Gigandipus* a length of approximately 20 feet, provided the ratio of entire bodily length to that of the track remained the same.

Genus *Hyphepus* E. Hitchcock

E. Hitchcock 1858, pp. 97, 180.

Lull 1904A, p. 493; 1915, p. 193, fig. 47.

Generic Characters.—Bipedal, tetradactyl, digitigrade. Hallux incumbent, curved sharply backward, anterior claws rarely present. Three anterior digits connected by a web-like membrane, hence the generic name (a web-footed animal). Tail trace present.

Discussion.—*Hyphepus* resembles *Gigandipus* although very much smaller. The character and position of the hallux are similar and the apparent absence of claws on the three anterior toes may be an accident of impression, as in the first published figures of *Gigandipus*. The tail trace is present in both genera.

***Hyphepus fieldi* E. Hitchcock**

E. Hitchcock 1858, pp. 97, 180, pl. 17, fig. 2; pl. 35, fig. 11; pl. 41, fig. 2; pl. 42, fig. 2.

Lull, 1904A, p. 493; 1915, p. 193, fig. 47.

Holotype.—Cat. No. 1/3 A. C., on micaceous shale, from Turners Falls, Mass.

Specific Characters.—Pes: Lateral toes rarely showing a claw, middle toe attenuated but distinct; claw if present is often obscured by the tail trace which generally passes directly through the track.

Length of digit I, 26 mm.; of II, 77 mm.; of III, 110 mm.; of IV, 80 mm. Length of the foot, 112-126 mm.; between lateral tips, 70 mm. Projection of digit III beyond the lateral toes, 50 mm. Divarication of digits I and II, 118°; II and III, 23°; III and IV, 28°; of the lateral toes, II and IV, 50°.

Length of pace, 152 mm.; width of trackway, 135 mm. Pes angulation, 5°, inward.

Interpes distance (heels), 50 to 75 mm.

Ratio of foot to pace, as 1 to 1.37.

Localities.—Lily Pond, Gill, and Turners Falls, Mass.

Geologic Distribution.—Upper (Portland) series of shales, etc.

Geologic Distribution.—Upper (Portland) series of shales, etc.

Infraorder Prosauropoda

Group III. Huge, gait bipedal; manus imprint may appear when stopping.

Pes: plantigrade, tetradactyl.

Manus: tetradactyl or pentadactyl, relatively small.

Genus, *Otozoum*.

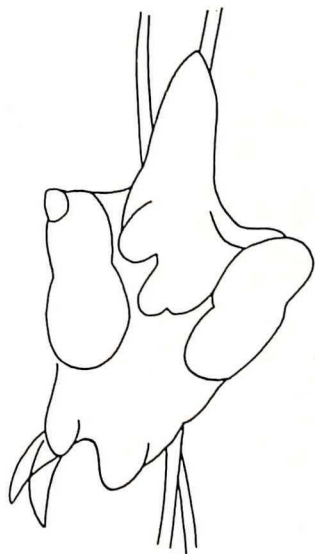


FIGURE 55.

Hyphepus fieldi Hitchcock, after Lull, from the type Cat. No. 1/3 A. C. A composite of two impressions showing variation in position of hallux claw and tail trace.

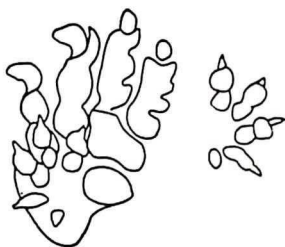


FIGURE 56.
Otozoum trackway, after Hitchcock,
one-sixteenth natural size.

Genus *Otozoum*

E. Hitchcock

E. Hitchcock 1847, p. 34; 1858, p. 123.

Lull, 1904A, p. 513; 1915, p. 222.

Generic Characters:—“Bipedal, Manus rarely present in the trackway. Pes plantigrade, functionally tetradactyl, hallux non-rotated. Digits broad with well marked phalangeal pads; claws more or less rounded. Manus apparently pentadactyl, relatively small. Occasional tail trace.”

Discussion:—This genus appears abruptly toward the close of Newark deposition [Portland series], being represented by at least two species, the huge *O. moodii* from South Hadley, Mass. [type locality] and Portland, Conn., and a smaller one occurring in the Turners Falls region. The so-called “web” (Hitchcock, 1858, p. 123) proves to be nothing more than the wave of plastic mud displaced by the animal’s weight, as certain specimens, such as Cat. No. 680, Wesleyan University collection clearly show. The “web” is convex where the phalangeal impressions are concave, and the dermal texture so strikingly impressed upon the actual track, abruptly ceases when the “web” is reached.

The smaller species, *O. minus*, shows no trace of the "web".

If the manus touched the ground with any degree of frequency, its imprint was obliterated by that of the pes, for in only two known instances in the same trackway, is the manus impression preserved. The disproportion of the manus and pes is so great that an habitually quadrupedal gait is highly improbable.

As Hitchcock says, "*Otozoum* is found through almost the entire valley, at the north in the Turners Falls region, at Moody's corner, Mt. Holyoke, and at Portland, Connecticut" which, however, is a total range of not more than one hundred miles. There is as yet no sign of the genus elsewhere nor any form known among the skeletal remains which from the foot structure and relative proportions could have made the tracks. If it was dinosaurian, it could not have been a Theropod other than one whose habits, like those of the *Saurischia*, were beginning to change toward an herbivorous dietary. It does not resemble the recognized Predentates, as represented by *Anomæpus*, at all.

In my reconstruction of *Otozoum moodii* (see fig. 100) the general proportions of the body and limbs were suggested by those of *Plateosaurus*, contemporaneous in time, although not geographically. *Plateosaurus* is now considered a member of the Prosauropoda in which the trend toward an herbivorous diet is already indicated.

Otozoum moodii E. Hitchcock

E. Hitchcock 1847, p. 55, fig. 1; 1848, p. 214, pl. 12, fig. 1; 1858, p. 123, pl. 22; pl. 23, fig. 1; pl. 33, figs. 4, 5; pl. 46, fig. 5.

Lull 1904A, p. 513, pl. 72, figs. E, F, G.; 1915, p. 223, pl. 12, text figs. 74, 75.

Type Specimens.—Cat. No. 5/14, A. C., in high relief on coarse sandstone from Moody's corner, South Hadley, Mass.; also Nos. 4/4 and 4/1. The counterpart of the latter, No. 3/1, is also preserved, but the layer of red mud on which the animal actually walked could not be saved.

Specific Characters.—Manus: Five-toed, toes turned outward. Length of digit I, 90 mm.; of II, 98 mm.; of III, 92 mm.; of IV, 80 mm.; of V, 56 mm. Length of hand, 206 mm. Divarication of digits I and II, 38°; of II and III, 25°; of III and IV, 50°; of IV and V, 57°. Phalangeal formula, 2, 2, 2, 2, 1. Claws when present more or less acuminate.

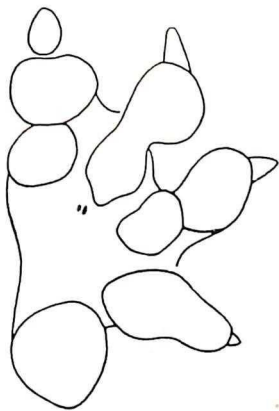


FIGURE 57.

Otozoum moodii Hitchcock,
fore footprint modified
after Lull, from Cat. No.
5/14 A.C., one-fourth natural size.

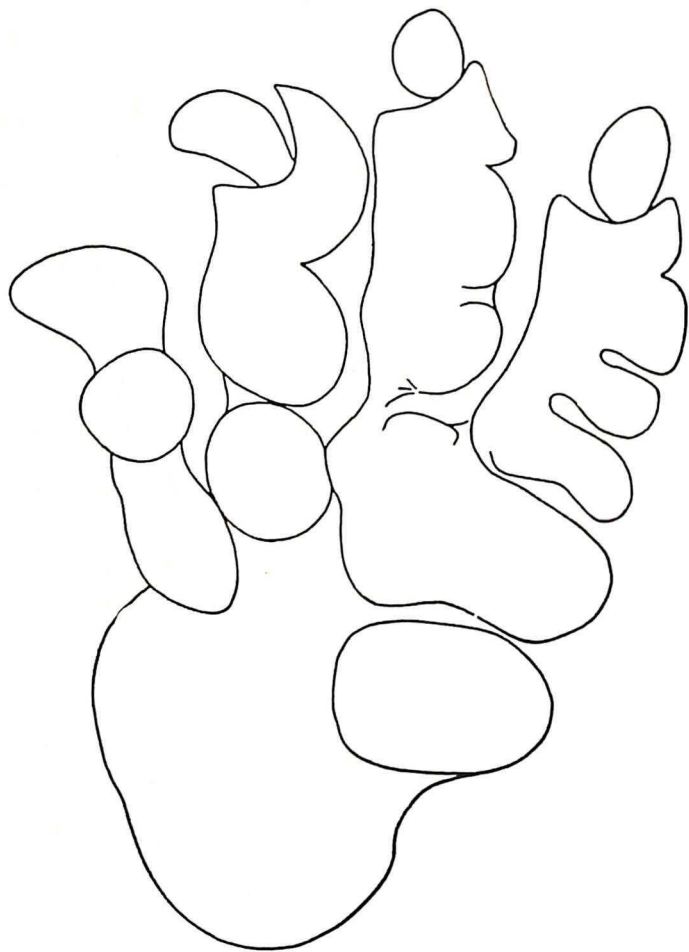


FIGURE 58.
Otoszom moodii Hitchcock, hind footprint, modified after Lull,
 from Cat. No. 4/1 A. C. one-fourth natural size.

Pes:—Four-toed. Length of digit I, 196 mm.; of II, 230 mm.; of III, 192 mm.; of IV, 202 mm. Length of the foot, 490 mm.; between lateral tips, 380 mm. Divarication of digits I and II, 25°; of II and III, 4°; of III and IV, 10°; of I and IV, 37°. Length of the pace 800 mm.

Ratio of foot to pace, as I is to 1.625. Phalangeal formula, 2, 2, 3, 4. Pes angulation, outward 10°. Interpes distance from middle of heel, 126 mm. Width of trackway, 680 mm.

Localities:—Moody's corner, South Hadley, Mass., and Portland, Conn.

Discussion:—One specimen in the Shepard collection at Amherst has a very short hallux in the pes, reaching only to the base of digit II, while in the type the hallux reaches to the line between the first and second phalanx. Of the single pair of manus tracks on Cat. No. 5/14 one print lies upon that of the right pes, the other outside of the trackway entirely, so that the two manus prints were apparently not made by the animal that made the pes prints at that time, but subsequently. Hitchcock believed that the manus prints were made first, but if that were true one of the manus prints would surely have been obliterated by the much heavier pes.

The appended track pattern is from the relief tracks so that it is the mirror image of the actual trail, and the manus impression lying on that of the pes is that of the opposite side. Right manus on left pes; left manus beyond the limit of the trackway on the left side.

Otozoum minus Lull

Lull 1915, p. 225, fig. 76.

Holotype:—Cat. No. 2046 Y. P. M., an isolated imprint of the left pes, on fine, dark gray siltstone from the Horse Race, Montague, Mass.

Geologically near the summit of the upper (Portland) series of sandstones, and toward the close of Newark time.

Specific Characters:—Manus: unknown. Pes: Length of digit I, about 120 mm.; of II, 128 mm.; of III, 140 mm.; of IV, 130 mm. Length of the foot, 264 mm. Distance between lateral tips, II and IV, 104 mm. Divarication of digits I and II, 17°; of II and III, nearly parallel; of III and IV, 20°; of I and IV, 38°. As the several specimens in the Yale collection are isolated prints, no general picture of the pace is unknown.

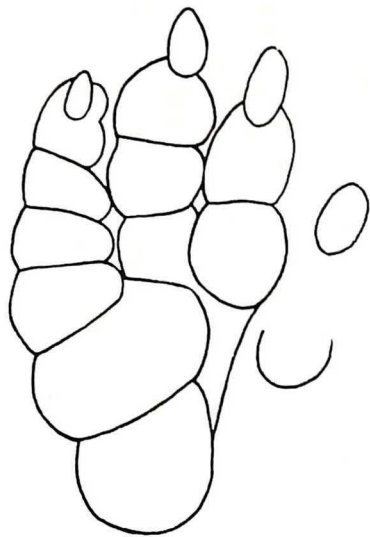


FIGURE 59.

Otozoum minus Lull, after Lull, from the type Cat. No. 2046 Y. P. M. one-fourth natural size.

the trackway can be formed. Even

Localities:—Horse Race, Turners Falls, and ? the canal at Montague, Mass.

Discussion:—Hitchcock 1858, p. 125, in speaking of *Otozoum* wrote: "Turners Falls at the ferry is another locality for these tracks. From the small size of some of the specimens there, I have suspected that they were made by a second species; but my specimens are somewhat broken

and I leave it for others to decide this question." This, the present author has attempted: but in all this ichnological study the factors of age and possible sex variation have not been sufficiently evident.

Otozoum caudatum C. H. Hitchcock

C. H. Hitchcock 1871, p. xxiv; 1889, pp. 119, 127.

Lull, 1904A, p. 514; 1915, pl. 12, B.

"*Otozoum caudatum* was recognized twenty years ago in the Museum of Wesleyan University, the slab coming from Portland, Conn. It differs from the *O. moodii* chiefly in the forward direction of the thumb. The mark of a tail does not necessarily indicate its presence in one species and absence in the other" (Hitchcock).

Discussion:—"The present author seriously questions the validity of this species, which is distinguished from *O. moodii* only [?] by the presence of a tail trace which could readily occur in *O. moodii* provided the specimens showed the animal's track * * * just before stopping. The other character, that of a forwardly directed 'thumb' (hallux) as against a recurved one in *O. moodii* is hardly a valid distinction for the reason that the curvature is not a constant character, in fact it is of rare occurrence" (Lull).

Type, No. 183, Wesleyan University collection from Portland, Conn.

Order ORNITHISCHIA

Suborder Ornithopoda

Group IV. Herbivorous, unarmored dinosaurs of moderate size. Gait bipedal, quadrupedal while at rest.

Family ANOMÆPODIDÆ

Family Characteristics.—Bipedal in gait, the manus impressing only when resting. Pes tetradactyl, digitigrade, with elongated metatarsal segment. Hallux semi-rotated, sub-functional and rarely impressed. Manus pentadactyl.

Footprint genera: *Anomæpus*, *Sauropus*, *Apatichnus*.

Genus *Anomæpus* E. Hitchcock

E. Hitchcock 1848, p. 220; 1858, p. 55.

Lull 1904A, p. 500; 1915, p. 208.

Generic Characters.—Bipedal in gait, the manus impressing only when seated. Pes: tetradactyl, but functionally tridactyl, digitigrade with an elongated metatarsal segment in evidence when the animal rests. Hallux half rotated, claw occasionally impressing. Limbs moderately long. Tail trace when slowing, but never dragging when moving at a normal gait.

Considerable weight is borne on the manus when the animal is seated and occasionally there may be impressions of the breast.

A heart-shaped imprint between the elongated tarsal portions of the feet has been interpreted by Lull as that of a possible callosity beneath the distal ends of the combined ischial bones; but which Hitchcock thought was made by the end of a truncated tail. This may be present when a normal tail trace is also seen.

The ischial imprint is also present in the genus *Sauropus*.

Eight species of *Anomæpus* have been described: *A. crassus*, *cuneatus*, *curvatus*, *gracillimus*, *intermedius*, *isodactylus*, *minimus*, and *scambus*, of which the last is the genotype.

The affinities of the genus lie with the Orthopodous, Camptosaur-like dinosaurs.

***Anomæpus scambus* E. Hitchcock**

E. Hitchcock 1848, p. 222, pl. 13, figs. 1-6.

Anomæpus minor E. Hitchcock 1858, p. 57, pl. 9, figs. 1-2; pl. 34, fig. 2.

Lull 1904A, p. 500, fig. 18; 1915, p. 209, fig. 61.

Cotypes.—Cat. Nos. 16/5 and 34/40 A. C., on red shale, the latter from Turners Falls, Mass.

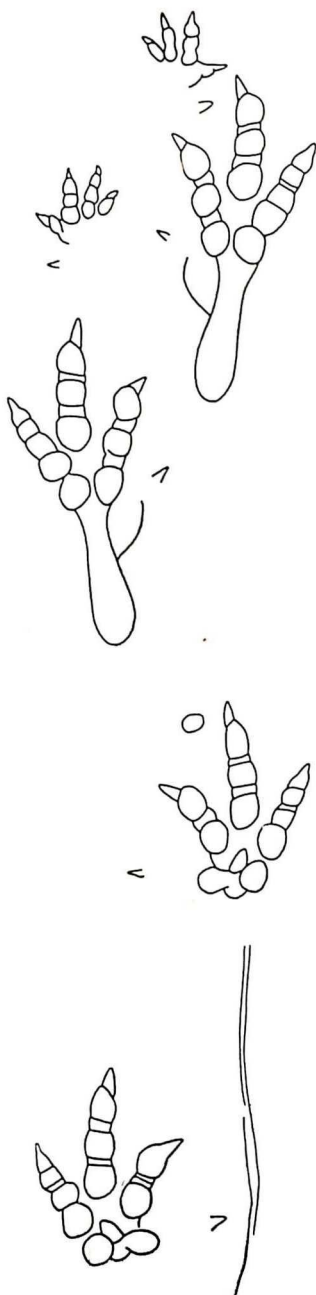


FIGURE 60.
Anomæpus trackway, original,
one-fourth natural size.

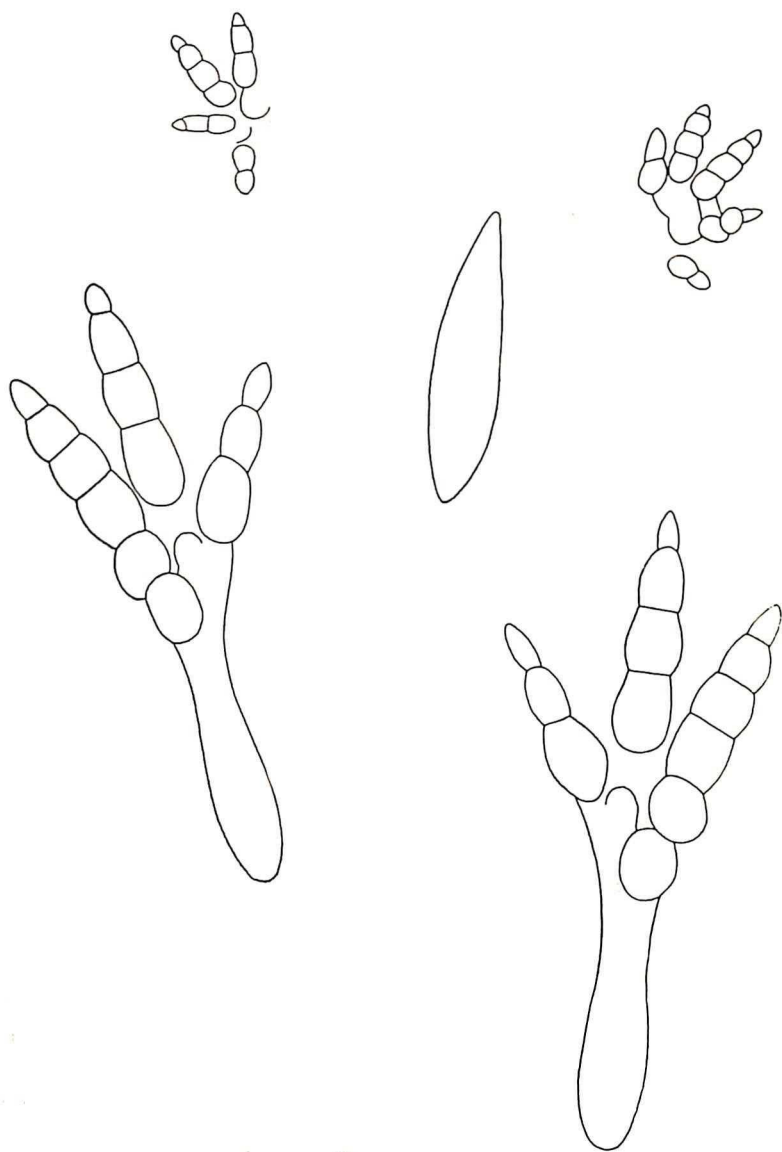


FIGURE 61.

Anomæpus scambus Hitchcock, after Lull, from Cat. No. 16/5 A. C.
All four feet of seated animal with impression of
the breast, one-half natural size.

Specific Characters:—Manus: Length of digit I, 24 mm.; of II, 29 mm.; of III, 32 mm.; of IV, 24 mm.; of V, 15 mm. Divarication of digits I and II, 17.5° to 43° ; of II and III, 22° to 29° ; of III and IV, 24° to 50° ; of IV and V, 55° to 87° ; of I and V, 120° to 152° .

Pes: Length of digit I unknown; of II, 49 to 57 mm.; of III, 60 to 80 mm.; of III and IV, 63 to 83 mm. Length of the standing foot, 95 mm.; of foot and heel (seated), 168 to 210 mm. Between lateral tips, 62 mm. Divarication of digits II and III, 20° to 35° ; of III and IV, 22° to 23° ; of the lateral digits, II and IV, 42° .

Length of the pace, 230 mm.; width of the trackway, 200 mm.

Ratio of foot to pace, as 1 to 2.41; pes angulation 0° to 20° outward.

Localities:—Ferry above and at Turners Falls, Field's orchard, in Gill, Moody's corner, South Hadley, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—Instead of showing the mark of a so-called "ischial callosity" when seated, as in *Anomæpus intermedius*, the type of *A. scamus* shows a lenticular imprint of the breast region of the ventral surface, as though more weight were borne on the manus and the body more nearly horizontal in the quadrupedal posture. None of the specimens referred to this rare species gives evidence of the hallux or of a tail trace.

Anomæpus intermedius

E. Hitchcock

Ethyopus minor (in part) E. Hitchcock 1848, p. 179.

Brontozoum isodactylus (in part) E. Hitchcock 1858, p. 69.

Apatichnus holyokensis C. H. Hitchcock 1889, pp. 118, 153.

E. Hitchcock, 1865, pp. 2, 7, pl. 1, fig. 1; pl. 15, fig. 1.

Lull 1904A, p. 501, figs. 19-21; 1915, p. 210, figs. 62, 63.

Holotype:—Cat. No. 48/1 A. C. On reddish sandstone from the Ferry at Turners Falls, Mass.

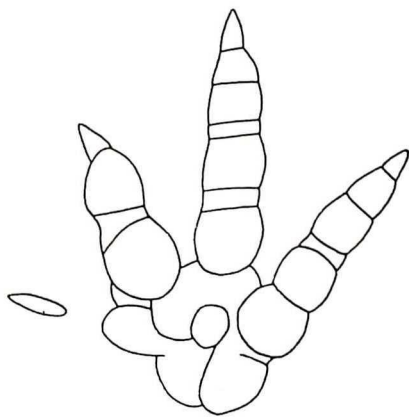


FIGURE 62.

Anomæpus intermedius Hitchcock,
hind foot of walking animal, modified
after Lull, from the type, Cat. No. 48/1 A. C.,
one-half natural size.

Specific Characters:—Manus: Length of digit I, 15 mm.; of II, 28 mm.; of III, 30 mm.; of IV, 23 mm. Divarication of digits I and II, 33° ; of II and III, 22° ; of III and IV, 68° ; of IV and V, 25° .

Pes: Length of digit II, 52 mm.; of III, 73 mm.; of IV, 57 mm.; of the standing foot, 105 mm.; of the seated foot including the heel, 173 mm.; between lateral tips, 80 mm. Divarication of digits I and II,

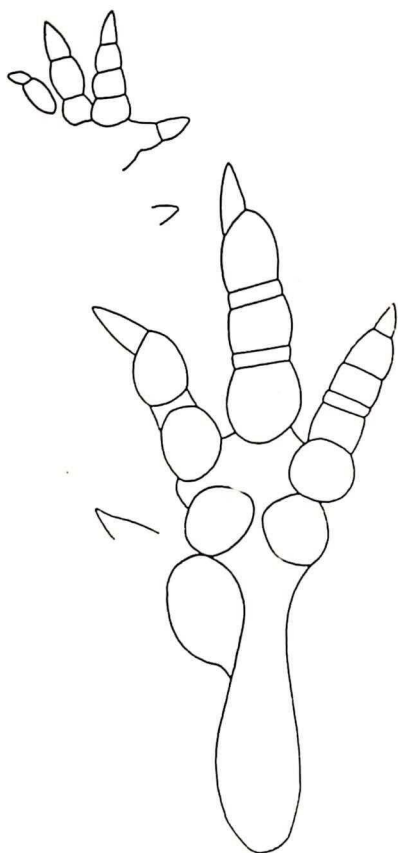


FIGURE 63.
Anomæpus intermedius Hitchcock,
fore and hind feet of seated animal,
modified after Lull, from the type, Cat. No.
481 A. C. one-half natural size.

56°; of II and III, 20°; of III and IV, 35°; of the lateral digits, II and IV, 56°.

Length of pace varies in the same animal from 120 to 205 mm. Width of trackway, 150 to 180 mm.

Ratio of foot to pace, as 1 to 2; to average pace, as 1 to 1.7. Pes angulation, 0° to 25° inward.

Localities:—Ferry above and at Turners Falls, Field's orchard in Gill, South Hadley, Massachusetts; Wethersfield Cove, Conn.; and Whitehall, N. J.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Anomæpus intermedius* differs from *A. scamus* which it resembles in general size, in the greater relative stoutness of the foot, shorter heel, and greater divarication of the lateral digits in the foot. The seated animal shows the impression attributed to an ischial callosity and an occasional tail trace when slowing down to rest and upon rising again.

Anomæpus curvatus E. Hitchcock

E. Hitchcock 1865, p. 5, pl. 1, fig. 2; pl. 15, fig. 2.
Lull 1904A, p. 502, fig. 22; 1915, p. 212, fig. 64.

Holotype:—Cat. No. 52/10, A. C., from the Lily Pond, Gill, Mass.
Cat. No. 3393 Y. P. M. is a portion of the same slab as the holotype.

Specific Characters:—Manus unknown. Pes: Length of digit II, 50 mm.; of III, 64 mm.; of IV, 55 mm. Length of foot, 98 mm.; between lateral tips, 77 mm. Divarication of digits II and III, 20°; of III and IV, 35°; of the lateral digits, II and IV, 50°.

Length of pace, 230 to 250 mm; width of trackway, 110 to 138 mm.
Ratio of foot to pace, as 1 to 2.45.

Pes angulation, 20° inward.

Localities:—Turners Falls, Field's orchard and Lily Pond in Gill, South Hadley, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Anomæpus curvatus* differs from *A. intermedius* in being somewhat more slender, in the inward curvature of the toes and the less divarication of the outer digits. *Anomæpus curvatus* resembles *A. intermedius* so closely that it is difficult always to distinguish them. It may prove to be only a variety of *intermedius*.

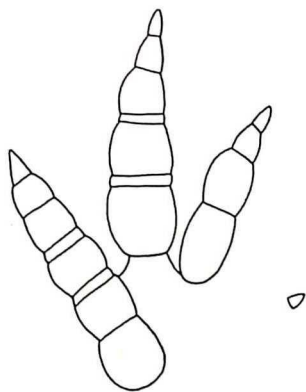


FIGURE 64.

Anomæpus curvatus Hitchcock, after Lull, from the type Cat. No. 52 10 A. C. one-half natural size.

Anomæpus gracillimus (E. Hitchcock)

Ornithoidichnites gracillimus E. Hitchcock 1844, p. 305.

Eubrontes gracillimus E. Hitchcock 1845, p. 23.

Brontozoum gracillimum E. Hitchcock 1848, p. 175, pl. 2, fig. 3.

Grallator gracillimus E. Hitchcock 1858, p. 73, pl. 13, fig. 5; pl. 19, fig. 2.

C. H. Hitchcock in E. Hitchcock 1865, p. 6.

Lull 1904A, p. 504; 1915, p. 214, fig. 67.

Holotype:—Cat. No. 50/1 A. C., on red sandstone from Turners Falls, Mass.

Specific Characters:—Manus unrecorded in the type; but apparently present in Cat. No. 3396, Y. P. M., from the Lily Pond, Gill, Mass.

Pes:—Dimensions from type: Cat. No. 50/1 A. C.

Length of digit II, 39 mm.; of III, 50 mm.; of IV, 46 mm.; of the foot, 64 mm.; between lateral tips, 60 mm.; projection of digit III beyond the others, 18 to 22 mm. Divarication of digits II and III, 34° ; of III and IV, 26° ; of the lateral digits, II and IV, 57° . Pes angulation, 0° to 10° . Interpes distance, 40 mm.

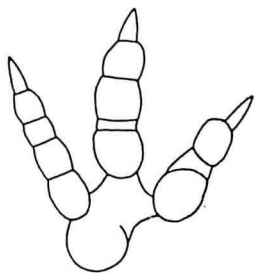


FIGURE 65.

Anomæpus gracillimus (Hitchcock) after Lull, one-half natural size.

Length of step, 180 to 200 mm. Ratio of foot to average step, as 1 to 2.82.

Manus:—from Cat. No. 3396 Y. P. M. Length of digit I, 14 mm.; of II, 29 mm.; of III, 35 mm.; of IV, 45 mm. Divarications not recorded.

Localities:—Ferry above and at Turners Falls, Gill, Dickinson quarry in South Hadley, Chicopee Falls, Mass.; Wethersfield, Middlefield and North Branford, Conn.

Geological Distribution.—Geologically the Massachusetts and Wethersfield localities are from the upper (Portland) series, while those of Middlefield and North Branford are from the upper (posterior) shales, which makes *Anomæpus gracillimus* the earliest recorded species of the genus in time.

Discussion:—This species differs from *A. minimus*, its nearest ally, in point of size, in being a somewhat larger and heavier track, resembling *A. intermedius* more nearly in general appearance.

The heel or metatarsus of a seated individual is as yet unknown.

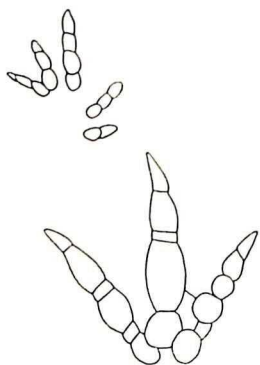


FIGURE 66.

Anomæpus minimus
Hitchcock, after Lull, from
the types Cat. Nos. 55/21
and 55/112 A. C.
one-half natural size.

Anomæpus minimus E. Hitchcock

E. Hitchcock 1865, p. 5, pl. 2, fig. 2.

Lull 1904A, p. 503, fig. 24; 1915, p. 213, fig. 66.

Holotype:—Cat. No. 55/112 A. C., from Field's orchard, Gill, Mass.

Plesiotype:—Cat. No. 55/21, A. C. (figured by Lull), same locality.

The smallest *Anomæpus* thus far described, but so close to *A. gracillimus* in general proportions that the one may sometimes be mistaken for the other.

Specific Characters:—*Manus*: pentadactyl, with blunted claws. Length of digit I, 12 mm.; of II, 14 mm.; of III, 21 mm.; of IV, 14 mm.; of V, 10 mm. Divarication of digits I and II, 40°; of II and III, 25°; of III and IV, 48°; of IV and V, 28°. Manus impression in front of and slightly within that of the pes.

Pes:—Tridactyl with slender digits, terminating in acuminate claws. Hallux absent in known specimens. Length of digit II, 35 mm.; of III, 50 mm.; of IV, 33 mm.; of the foot, 54 mm. Metatarsus (heel) unknown. Divarication of digits II and III, 40°; of III and IV, 35°; of the lateral digits, II and IV, 72°. Distance between lateral tips, 55 mm. Length of pace, 110 to 120 mm. Ratio of foot to average pace, as 1 to 2.3.

Localities:—Ferry at Turners Falls, Field's orchard, Gill, and South Hadley, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—Possibly some of the specimens referred to *A. gracilimus* may belong to *A. minimus*. Their inclusion would widen the range of this species.

Anomæpus cuneatus C. H. Hitchcock

C. H. Hitchcock 1889, p. 118, 125.

Lull 1904A, p. 505; 1915, p. 215.

Holotype:—Cat. No. 105, Mount Holyoke collection, from Dickinson Quarry, South Hadley, Mass. (destroyed by fire).

Specific Characters:—Manus: but three digits impressing in the only known track. Length, 24 mm.; including what may be a wrist impression, 30 mm.; distance between lateral tips, 20 mm.

Pes:—Length of digit II, 48 mm.; of III, 58 mm.; of IV, 44 mm. Distance between lateral tips, 43 mm. Divarication of digits II and III, 36.5°; of III and IV, 7.5°; of the lateral digits, II and IV, 43.5°.

Length of step, 330 to 460 mm. Width of trackway, 178 mm.

Localities:—Howland's farm in Gill, Lily Pond, Dickinson Quarry in South Hadley, Mass.; Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion:—This species was very inadequately described by C. H. Hitchcock in 1889. The type specimen was subsequently lost in the fire which destroyed the Mt. Holyoke collection. Its counterpart, however, is preserved in the Dartmouth collection at Hanover, N. H.

The type was fortunately studied by Lull, who amplified the description somewhat in 1915, but no figure was made nor was the length of the foot recorded.

It has not been recognized in the Yale collection.

Anomæpus crassus (C. H. Hitchcock)

Apatichnus crassus C. H. Hitchcock 1889, pp. 118, 132, 134.

Lull, 1904A, p. 503, fig. 23; 1915, p. 212, fig. 65.

Holotype:—Cat. No. 50:4:1, on a large slab of red sandstone in the Geological Museum of Rutgers University, from Whitehall (Towaco township), N. J.

Specific Characters:—Manus: Length of impression, 60 mm.; its width, 60 mm.

Pes:—Length of digit II, 85 mm.; of III, 102 mm.; of IV, 83 mm.;

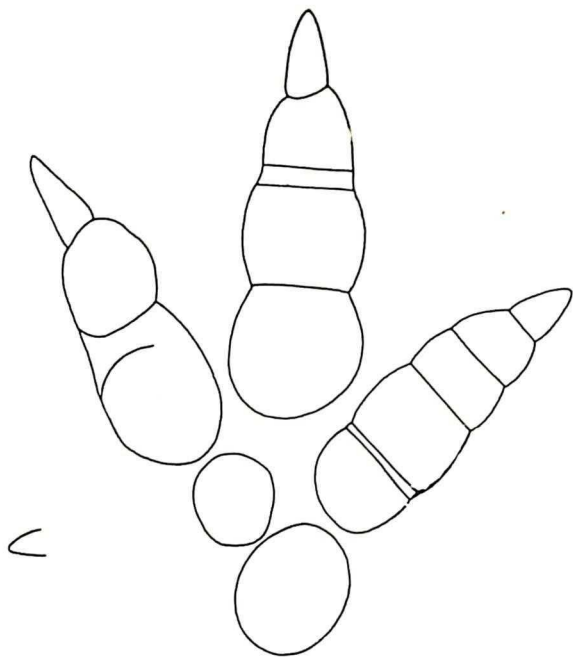


FIGURE 67.

Anomæpus crassus (C. H. Hitchcock) after Lull,
from the type, Cat. No. 50:4:1 Rutgers Museum,
one-half natural size.

length of the foot, 160 mm.; between lateral tips, 140 mm. Divarication of digits I and II, 80° ; of II and III, 32° ; of III and IV, 40° ; of the lateral digits, II and IV, 72° .

Length of the pace, 387 mm. Ratio of foot to pace, as 1 to 2.42.

Localities:—Whitehall, N. J. Turners Falls, Horse Race, Montague, Ferry at Gill, Massachusetts.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Anomæpus crassus* resembles *A. intermedius*, but is considerably larger and more robust and the hallux is rotated farther to the rear. A seated individual showing the heel is as yet unknown.

Anomæpus crassus may prove to be identical at least in part with *E. Hitchcock's Eubrontes expansus* described in 1841 and 1848, but abandoned after 1848, no reason being given. What assignment was made of the several specimens mentioned in 1848 is not recorded.

The dimensions of *E. expansus* compared with those of *A. crassus* and together with *E. Hitchcock's* figure (1848, pl. 3, fig. 1) show at least approximation. Should they prove to be identical the specific name *expansus* would have long priority.

Anomæpus isodactylus

C. H. Hitchcock

C. H. Hitchcock 1889, pp. 118, 124.

Lull 1904A, p. 505, fig. 25; 1915, p. 215, fig. 68.

Holotype:—Cat. No. 128, and its counterpart, No. 142, Mt. Holyoke collection, from South Hadley, Mass. (destroyed by fire).

Specific Characters:—Manus (from No. 2097 Y. P. M.): four digits impressed; length of digit I, 30 mm.; II, 36 mm.; III, 40 mm.; IV, 30 mm.; length of the hand, including a wrist impression, 83 mm. Divarication of digits I and II, 20°; II and III, 23°; III and IV, 50°, I and IV, 93°.

Pes— (from type): Length of digit I, 43 mm.; II, 63 mm.; III, 72 mm.; IV, excluding the sole pad, 70 mm.; including sole pad, 101 mm.; entire foot, 115 mm.; including the heel, 230 mm. Between lateral tips, 100 mm. Divarication of digits I and II, 50°; II and III, 29°, III and IV, 30°; of the lateral digits, II and IV, 48°.

The basal pads of the hallux are impressed as well as the claw.

Length of pace, 205 mm.; of the stride, 330 mm. Ratio of foot to pace, as 1 to 1.78.

Localities:—Turners Falls, Dexter Marsh's Quarry in Montague, Gill, and Dickinson Quarry, South Hadley, Mass.

Genus *Apatichnus* E. Hitchcock

E. Hitchcock 1858, p. 99.

Lull, 1904A, p. 508; 1915, p. 220.

Generic Characters:—Quadrupedal, digitigrade to semi-plantigrade; pes functionally tridactyl, but with the hallux claw generally impressing and semi-rotated. Manus with four or five digits, three of which are inclined inward toward the median line of march. Phalangeal pads and acuminate claws on the pes. Caudal trace.

Discussion:—*Apatichnus* is distinguished from its nearest ally, *Anomæpus*, largely by the shorter hallux, and greater divarication of digit

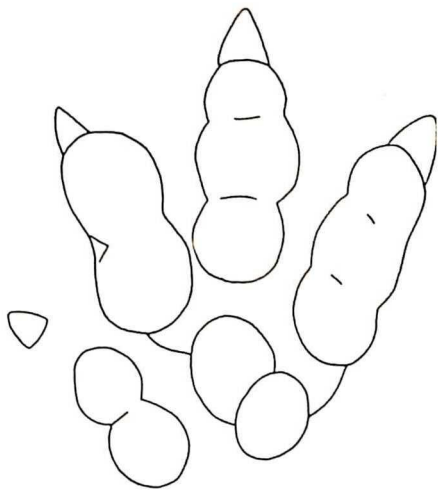


FIGURE 68.

Anomæpus isodactylus C. H. Hitchcock, after Lull, from Cat. Nos. 128 and 142 (counterparts) Mt. Holyoke College (destroyed by fire), one-half natural size.

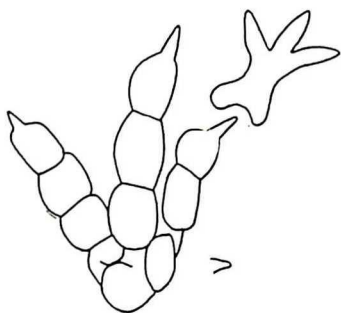
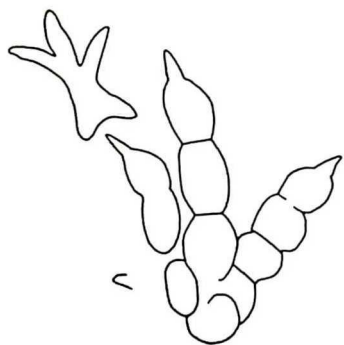


FIGURE 69.
Apatichnus trackway, original,
one-half natural size.

IV of the pes. The distinction given by Hitchcock, of the presence of a hallux impression in the former genus and not in the latter, does not hold, for both genera possess it.

Several species have been referred to *Apatichnus*: the genotype, *A. circumagens*, and also *A. crassus* C. H. Hitchcock, *A. holyokensis* C. H. Hitchcock, and *A. bellus* E. Hitchcock. The last has been removed by Lull to *Batrachopus*, and the other two to *Anomæpus*. Lull has removed E. Hitchcock's *Gigantitherium minus* from that genus to *Apatichnus* so that there now appear to be two species of *Apatichnus*, *circumagens* and *minor*.

Apatichnus circumagens E. Hitchcock

E. Hitchcock 1858, p. 100, pl. 17, fig. 5; pl. 35, fig. 6.

Lull 1904A, p. 508, fig. 29; 1915, p. 221, fig. 72.

Holotype:—Cat. No. 21/2 A. C., on red micaceous sandstone from the Ferry at Turners Falls, Mass.

Specific Characters:—*Manus*: Much smaller than the pes and situated within and alongside of the anterior part of the pes imprint. Having four, possibly five digits, three of which are directed forward and inward toward the line of march. The fourth toe is widely offset—at least 70° from the axis of the hand. The rear is prolonged backward into a heel-like palm, which Hitchcock thought might represent a fifth toe. The length of the manus impression is about 38 mm.; its breadth, 25 mm. (measurements from Hitchcock).

Pes: with three toes bearing acuminate claws directed forward, the outer one (IV) being widely divergent. The hallux is small and only partially rotated.

Dimensions of the holotype, No. 21/2 A. C., are: Pes: Length of digit I, 25 mm.; of II, 35 mm.; of III, 62 mm.; of IV, 53 mm. Length of the foot, 75 mm. Between the lateral tips, 57 mm. Divarication of digits I and II, 53° ; of II and III, 18° ; of III and IV, 45° ; of the lateral digits, II and IV, 50° .

Average length of pace, 162 mm.; width of trackway, 114 mm.; pes angulation, 10° , inward; interpes distance between heels, 12 mm.

Ratio of foot to average pace, as 1 to 2.16.

Caudal trace sinuous; not always present.

Localities:—Turners Falls, Field's orchard in Gill, and South Hadley, Mass.

Geological Distribution:—Upper (Portland) shales and sandstones, high in the series.

Apatichnus minor (E. Hitchcock)

Gigantitherium minus E. Hitchcock 1858, p. 95, pl. 17, fig. 1; pl. 41, fig. 2; pl. 42, fig. 2.

Lull 1904A, p. 509, fig. 30; 1915, p. 221, fig. 73.

Holotype:—Cat. No. 1/3 A. C., on micaceous shale from the Lily Pond, Gill, Mass.

Specific Characters:—Manus: Unknown.

Pes: Length of digit I, ± 34 mm.; of II, 108 mm.; of III, 147 mm.; of IV, 140 mm. Projection of digit III beyond the lateral toes, 86 mm. Length of foot, 225 mm.; Distance between lateral tips, 160 mm. Divarication of digits I and II $\pm 86^\circ$; of II and III, 20° ; of III and IV, 40° to 43° ; of the lateral digits, II and IV, 60° .

Length of pace, 630 mm. Width of trackway, 167 mm.

Ratio of foot to pace, as 1 to 2.8.

Tail trace, breadth 37.5 mm.; straight, interrupted at each step.

Localities:—Ferry above and at Turners Falls, South Hadley, and (?) Moody's corner, Mass.

Geological Distribution:—High in the Upper (Portland) series.

Discussion:—The pes track of this form is about two and one half times as large as *A. circumagens*. The specific name belies this, but it was the lesser of the two species referred by Hitchcock to *Gigantitherium* and the specific name must be retained.

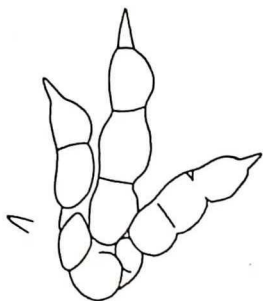


FIGURE 70.

Apatichnus circumagens
Hitchcock, after Lull,
from Cat. No. 23/8 A. C.
one-half natural size.

Otherwise, except for the presumed angle of the hallux with the axis of the foot, the resemblance between *minor* and *circumagens* is close.

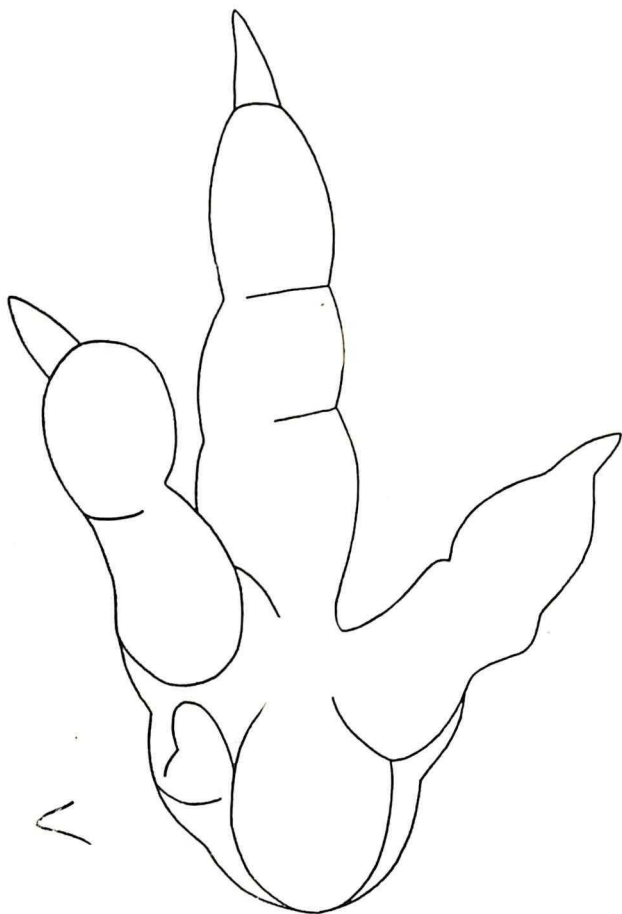


FIGURE 71.
Apatichnus minor (Hitchcock) after Lull, from the type
Cat. No. 1/3 A.C. one-half natural size.

Genus **Sauropus** E. Hitchcock

E. Hitchcock 1845, p. 24.

Fulicopus E. Hitchcock 1845, p. 23 (name without description).
Lull 1904A, p. 505.

Anomcepus (in part) E. Hitchcock 1848, p. 220.

Ethyopus (in part) E. Hitchcock 1848, p. 178.

Amblonyx E. Hitchcock
1858, p. 71.

Chimæra E. Hitchcock
1858, p. 118.

Chimærichnus C. H.
Hitchcock 1871, p. xxi (for
Chimæra preoccupied).

Sauropus Lull 1915,
p. 216.

Generic Characters:—Bipedal in gait, quadrupedal when resting. Pes: tridactyl, digitigrade; heel impressing only when seated. Foot compact with well defined phalangeal pads and blunted claws. Manus much smaller than the pes; pentadactyl, without distinct phalangeal pads or claws.

Discussion:—*Sauropus* is distinguished from *Anomæpus*, by the greater size, especially of the pes, less acuminate claws, less divarication of the digits and the absence of the sole pad in addition to the four phalangeal pads normally belonging to digit IV. An ischial callosity [imprint] may be present. Foot resembles that of *Anchisauripus* but is distinguished therefrom by the non-rotated hallux and by the occasional impression of the manus and long heel when the animal is resting.

But one species has been described although with a complex synonymy, *Sauropus barrattii*, the genotype.

Sauropus barrattii
(E. Hitchcock)

Sauroidichnites barrattii
E. Hitchcock 1837, p. 175;

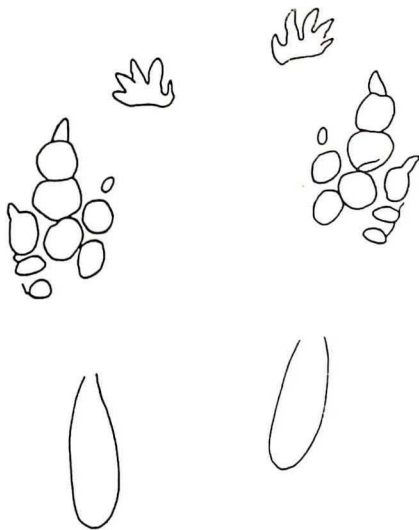
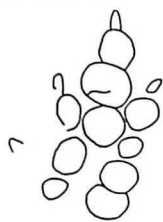


FIGURE 72.
Sauropus trackway, original
one-eighth natural size.

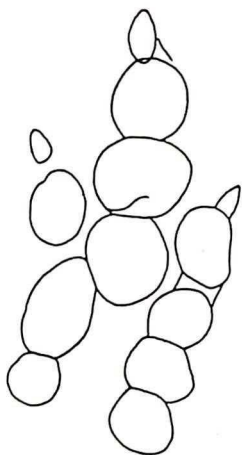


FIGURE 73.
Sauropus barrattii
Hitchcock, standing foot
after Lull, from
the type Cat. No. 1/1
A.C. one-fourth natural size.

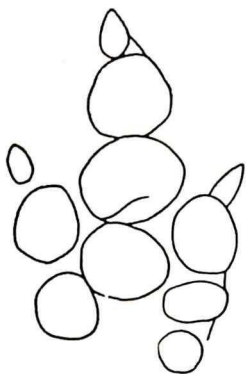


FIGURE 74.
Sauropus barrattii Hitchcock,
fore and hind foot of the seated animal,
after Lull, from Cat. No. 1/1 A.C.,
one-fourth natural size.

1841, pp. 477, 478, pl. 30, fig. 1.

Ornithoidichmites lyellii E.
Hitchcock 1843, pp. 257-258, pl. 11,
fig. 1.

Fulicopus lyellianus E. Hitch-
cock 1845, p. 23.

Æthyopus lyellianus E. Hitch-
cock 1848, p. 178, pl. 4, fig. 1.

Anomæpus barrattii E. Hitch-
cock 1848, p. 225, pl. 14, fig. 1.

Amblonyx lyellianus E. Hitch-
cock 1858, p. 71, pl. 13, fig. 2; pl.
38, figs. 1, 2; pl. 57, fig. 6.

Anomæpus major E. Hitchcock 1858, p. 56, pl. 8.

Chimæra barrattii E. Hitchcock 1858, p. 118, pl. 21, figs. 1, 3 (in part).

Chimærichnus barrattii C. H. Hitchcock 1871, p. xxi.

Fulicopus lyellianus Lull 1904A, pp. 506-508, figs. 26-28.

Sauropus barrattii Lull 1915, p. 217, figs. 69-71.

This species has the most complex synonymy of all because of the fact that separate names were given to the impression of the

hand, which was supposed to be that of a hind foot, and also to the foot both in the walking and again in the seated posture.

In 1837 Hitchcock described and figured the manus under the name of *Sauroidichnites barrattii*, which became, in the 1845 list, *Sauropus barrattii*. The pes was first described and figured under the

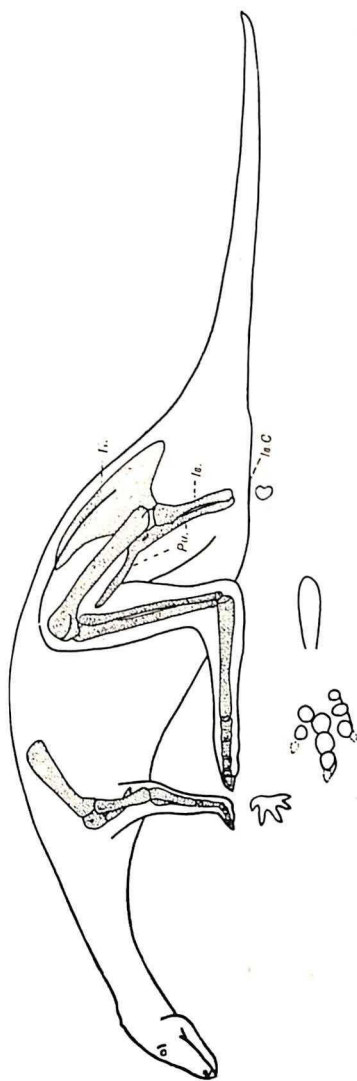


FIGURE 75.

Sauropus barrattii Hitchcock, restoration of the seated animal, after Lull; il, ilium; pu, pubis; is, ischium, is, c. mark of assumed ischial callosity, one-sixteenth natural size.

name of *Ornithoidichnites lyellii* in 1843, becoming *Fulicopus lyellianus* in the list of 1845. Thus both anatomically and by the laws of priority the name of the manus impression, *Sauropus barrattii*, takes precedence. This manus impression was called *Anomæpus barrattii* in the publica-

tion of 1848, while in 1858, what was supposed to be the same species was renamed *Chimæra barrattii*; but, while the fore foot figured (pl. 21, fig. 3) is the same as before, the hind foot (fig. 1) is new, although strongly suggestive of the *Anomæpus scambus* figured in 1848, pl. 13, fig. 3. In 1871, C. H. Hitchcock, finding the name *Chimæra* pre-occupied, substituted that of *Chimærichnus*. Of this series of names *Sauropus barrattii* alone is valid.

To return to the hind foot impression, *Fulicopus lyellianus* of the 1845 list was changed to *Athyopus lyellianus* in that of 1848 and to *Amblonyx lyellianus* in 1858. In 1858 Hitchcock further described what he supposed to be a new form, basing his description upon the impression of a seated individual which he called *Anomæpus major*. This animal Lull showed in 1904A (p. 507) to be not only the same species but the same individual as that which made the type track of *Fulicopus lyellianus*, both type impressions appearing on the same slab, Cat. No. 1/1 of the Amherst College collection, and both showing a peculiar unique distinction in the right foot. Thus no fewer than ten names in all have been given to this remarkable form.

* *Cotypes*.—Cat. No. 1/1 A. C., on reddish sandstone from Field's orchard, Gill, and Cat. No. 1/7 from the Lily Pond quarry at Gill, Mass.

Specific Characters.—Manus: Length of digit I, 31 mm.; II, 38 mm.; III, 40 mm.; IV, 33 mm.; V, 20 mm. Divarication of digits I and II, 6°; II and III, 32°; III and IV, 20°; IV and V, 26°.

Pes: Length of digit I, 83 mm.; II, 103 mm.; III, 147 mm.; IV, 156 mm.; entire foot, 220 mm., including heel, 427 mm.; breadth of heel, 50 mm. Distance between lateral tips, 110 mm. Divarication of digits I and II, 40°; II and III, 11.5°; III and IV, 14°; of the lateral digits, II and IV, 22°.

Length of pace, 765 mm. Width of trackway, 320 mm.

Ratio of foot to pace, as 1 to 3.48.

Pes angle, 10° to 15°, outward.

Localities.—Lily Pond, and Field's orchard in Gill, Mass.; not a wide-spread species though possibly some of the specimens properly referable to it have been referred to *Anchisauripus exsertus*.

Geological Distribution.—Upper (Portland) series.

Discussion.—The resting posture of *Sauropus* differs from that of *Anomæpus* in that in the former the bulk of the weight is borne upon the hind limbs, the manus making an extremely light, variable impression without phalangeal pads, and with more acuminate claws.

REPTILIA?

Incertæ Sedis

Group V. Bipedal forms with no manus imprint. Tridactyl or tetradactyl.

Short stride, medium trackway.

Genera: *Lagunculapes*, *Toxichnus*.

Genus *Lagunculapes* E. Hitchcock

E. Hitchcock 1858, p. 132.

Lull 1904A, p. 525; 1915, p. 242, fig. 99.

Generic Characters:—Small, bipedal, tetradactyl, digitigrade forms with widely radiating, clawless digits, expanding somewhat toward their tips; appearing more or less club- or flask-like. Hence the generic name.

But one species has been described, *Lagunculapes latus*, which thus becomes the genotype.

Lagunculapes latus E. Hitchcock

E. Hitchcock 1858, p. 132, pl. 24, fig. 1; pl. 45, fig. 4.

Lull 1904A, p. 525; 1915, p. 242, fig. 99.

Holotype:—Cat. Nos. 33/29 and 33/29 bis, counterparts. Amherst collection. On gray shale, from Turners Falls, Mass.

Specific Characters:—Pes: Length of digit I, 12 mm.; of II, 13 mm.; of III, 20 mm.; of IV, 15 mm.; of the foot, 21 mm.; between lateral tips (width of the foot), 31 mm. Divarication of digits I-II, 35°; of II and III, 53°; of III and IV, 75°; of the lateral digits, II and IV, 156°.

Length of the pace, 75 mm.; width of the trackway, 75 mm.

Ratio of foot to pace, as 1: 3.57.

Pes angulation, 30° to 70° inward. Pace angulation, 107°-136°.

Interpes distance, 11-63 mm.

Localities:—Turners Falls, Ferry, Gill, Canal at Montague, Mass.

Geological Distribution: Upper (Portland) series.

Discussion:—A very distinctive track; unlike any other and with rarely a caudal trace.

Apparently bipedal, the manus track not having been observed in at least four specimens.

Genus *Toxichnus* E. Hitchcock

E. Hitchcock 1865, p. 12.

Lull 1904A, p. 541; 1915, p. 262.

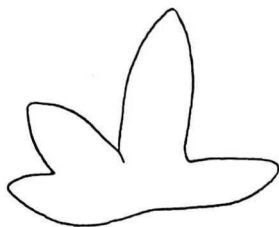


FIGURE 76.

Lagunculapes latus
Hitchcock after Lull.
from the type Cat. No. 33/29
A. C. natural size.

Generic Characters.—Bipedal, leptodactylous, tridactyl, without phalangeal pads or distinct claws. Digits straight or curved, arising from a narrow, elongate, curved base with intervals between the base of the toes.

Discussion.—Hitchcock's original description follows: "*Both Feet* —Leptodactylous, tetradactylous, digitigrade, toes all gracefully curved inward, except the innermost one, which is nearly straight."

There was but a single species described, *Toxichnus inæqualis*, based upon two specimens in the Amherst collection, Nos. 55/3 and 55/33, cotypes, and the generic and specific descriptions involve both of them, in spite of the fact that they are sufficiently unlike to belong to different genera. No. 55/33 bears ten impressions in a row, of hind feet only, and is the one shown in pl. 5, fig. 6 of the Supplement (1865). No. 55/3 on the other hand, shown on pl. 5, fig. 5, bears both fore and hind foot tracks and is the basis for the description of the hand, while that of the foot is apparently derived from No. 55/33. One specimen only shows the fore foot, and the hind feet in the two specimens are quite unlike.

The writer would, therefore, designate No. 55/33 as the type of *Toxichnus* and refer the other to some unknown form. As Hitchcock implies, it is quite *Harpedactylus*-like except for the absence of a heel running backward from the toes on the tracks, which may well be the result of gait rather than morphology, as in the case of *Harpedactylus crassus*, which is very similar in many respects, although larger than No. 55/33.

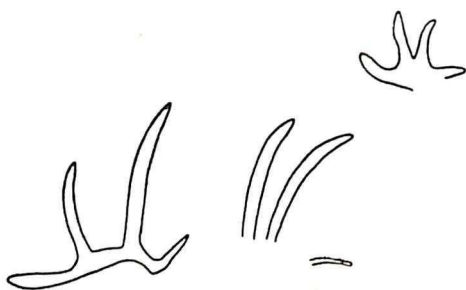


FIGURE 77.
Toxichnus inæqualis Hitchcock
after Hitchcock, one-half natural size.

Toxichnus inæqualis
E. Hitchcock

E. Hitchcock 1865, p. 12,
pl. 5, fig. 6.

Lull 1904A, p. 542; 1915,
p. 263, fig. 124 (in part).

Holotype.—Cat. No. 55/33,
A. C., ten impressions of the
hind feet, from Howland's
farm, Turners Falls, Mass.

Also specimens Nos. 2122
Y. P. M. and its counterpart
with four hind foot tracks
from Gill, Mass., and No. 3479

Y. P. M., also counterparts, bearing a single hind foot track from the
Ferry at Gill.
No. 2122 Y. P. M. is the specimen here figured (fig. 77) and be-
comes a plesiotype.

Specific Characters.—*Pes*: The form of this track is unique, resem-
bling the head of a trident spear, lacking the shaft. Tridactylous or
tetradactylous, including digits II to IV, possibly also No. V. Length

of digit II, 14 mm.; of III, 43 mm.; of IV, 28 mm.; of the foot, 48 mm. Distance between the lateral tips, 34 mm.; breadth of the basal mark, 25 mm. Divarication of digits II and III, 28°; of III and IV, 26°; of the lateral digits, II and IV, 49°.

Length of stride, 117 to 123 mm. Digits curved toward the median line, except No. II which is straight.

The dimensions of the plesiotype, Cat. No. 2122 Y.P.M., are somewhat smaller; but the track pattern (here shown, fig. 77) is more complete. Length of digit II, 10 mm.; of III, 30 mm.; of IV, 14 mm.; of the foot, 36 mm.; between lateral tips, 35 mm.; width of the basal mark, 27 mm. Divarication of digits II and III, 41°; of III and IV, 36°; of II and IV, 70°.

Length of pace, 83 mm.; of the stride, 125 mm. Width of trackway, 92 mm. Ratio of foot to pace, as 1 to 2.3.

Pes angulation, 23° inward; pace angulation, 95°. Interpes distance, 34 mm.

Toxichnus inaequalis tracks are difficult of interpretation for they are in every instance leptodactylous, which generally implies a slumping in of the mud after the foot is withdrawn, thus obscuring the true morphology of the animal's foot.

Localities:—Turners Falls, and Gill, Mass.

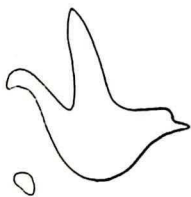
Geological Distribution:—Upper (Portland) series.

Discussion:—The second specimen, Cat. No. 55/3, which consists of a manus impression, and three digits of the pes, I have removed from *Toxichnus* for there are no parts in common with those of No. 55/33, which are comparable or similar, for in the type the fore foot is lacking and the hind foot is very different, resembling more nearly that of *Harpedactylus crassus* except for apparent incompleteness and smaller size. A further difficulty lies in Hitchcock's figure which is that of the slab under consideration, No. 55/3, and is correct. Hitchcock describes the manus as tridactyl with the toes relatively straight, whereas the figure shows a tetradactyl track with curved toes. The dimensions given are all too large for the figured specimens. Hitchcock goes on to say: "*On another specimen, the impressions quite perfect*," Tetradactylous. Length of the toes reckoning outwardly 0.25 inch [6 mm.]; 0.6 inch [14.5 mm.], 0.75 inch [19 mm.], 0.6 inch [14.5 mm.], and are evidently correspond quite closely with the manus in 55/3 and are evidently taken from the type. I have been unable thus far to identify the larger specimen.

Group VI. Bipedal, tetradactyl forms, digitigrade. No manus imprint; no phalangeal pads.

Large: *Anticheiropus*, *Polemarchus*.

Small: *Sillimanius*, *Eupalamopus*.

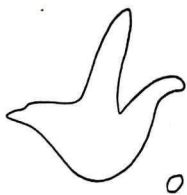
Genus *Anticheiropus* E. Hitchcock

E. Hitchcock 1865, p. 10.

Lull 1904A, p. 540.

Generic Characters.—Bipedal, digitigrade, tridactyl. Digits broad but without phalangeal pads. As the name, meaning 'thumb-foot', implies, one of the digits is offset from the middle one in a thumb-like manner, but in one species, *hamatus*, it is the fourth toe which is thus offset; while in *pilulatus* it seems to be the second digit. An ovoid mark in each form, impressed some distance behind and within that of the remainder of the track, may indicate the presence of a hallux which arose rather high upon the tarsus and which determines the sequence of the other toes.

Discussion.—But two species of this curious genus have been described, *Anticheiropus hamatus*, the genotype, and *A. pilulatus*. The former is known from a sequence of three foot marks, the latter from but a single track and its counterpart. They differ markedly in size as in other characters and both have an abnormal aspect. The real validity of these forms may only be proven by the discovery of more individuals of each.

*Anticheiropus hamatus* E. Hitchcock

E. Hitchcock 1865, p. 10, pl. 9, figs. 1, 2.

Lull 1904A, p. 541.

Holotype.—Cat. No. 51/17, A. C., on red shale from the Lily Pond, Gill, Mass. Three successive footprints.

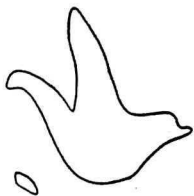


FIGURE 78.
Anticheiropus trackway
original, one-eighth
natural size.

Specific Characters.—Pes: Length of digit II, 85 mm.; of III, 110 mm.; of IV, 50 to 60 mm.; of the foot, 175 mm.; between lateral tips, 195 mm. Divarication of digits II and III, 20° to 40°; of III and IV, 90°; of the lateral toes, II and IV, 100°. (These are difficult to measure because of the curvature, especially of digit II.)

Length of pace, first and second steps, 354 mm., and second and third, 962 mm.; width of trackway unrecorded.

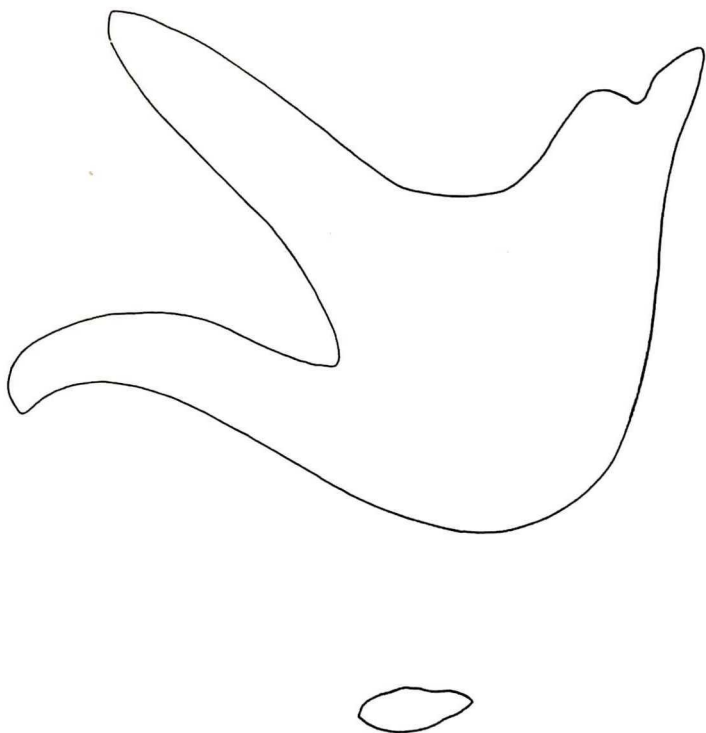


FIGURE 79.

Anticheiropus hamatus Hitchcock, after Hitchcock, from the type
Cat. No. 51/17, A. C. one-half natural size

Pes angulation, 10° inward.

Ratio of pes to average pace, as 1 to 3.76.

Locality:—Lily Pond, Gill, ?Montague, Mass.

Geological Distribution:—Upper (Portland) series.

***Anticheiropus pilulatus* E. Hitchcock**

E. Hitchcock 1865, p. 10, pl. 9, fig. 3.

Lull 1904A, p. 540.

Holotypes:—Cat. No. 10/4 and 10/5, A. C. Counterparts, on reddish, micaceous sandstone from Dexter Marsh's quarry in southwest Montague, Mass. A unique specimen regarded as a *lusus* from its discovery in 1842 until the publication of the Ichnological Supplement in 1865. The largest of the Connecticut Valley footprints!

A second, more symmetrical specimen is said to be in the Dartmouth College Museum.

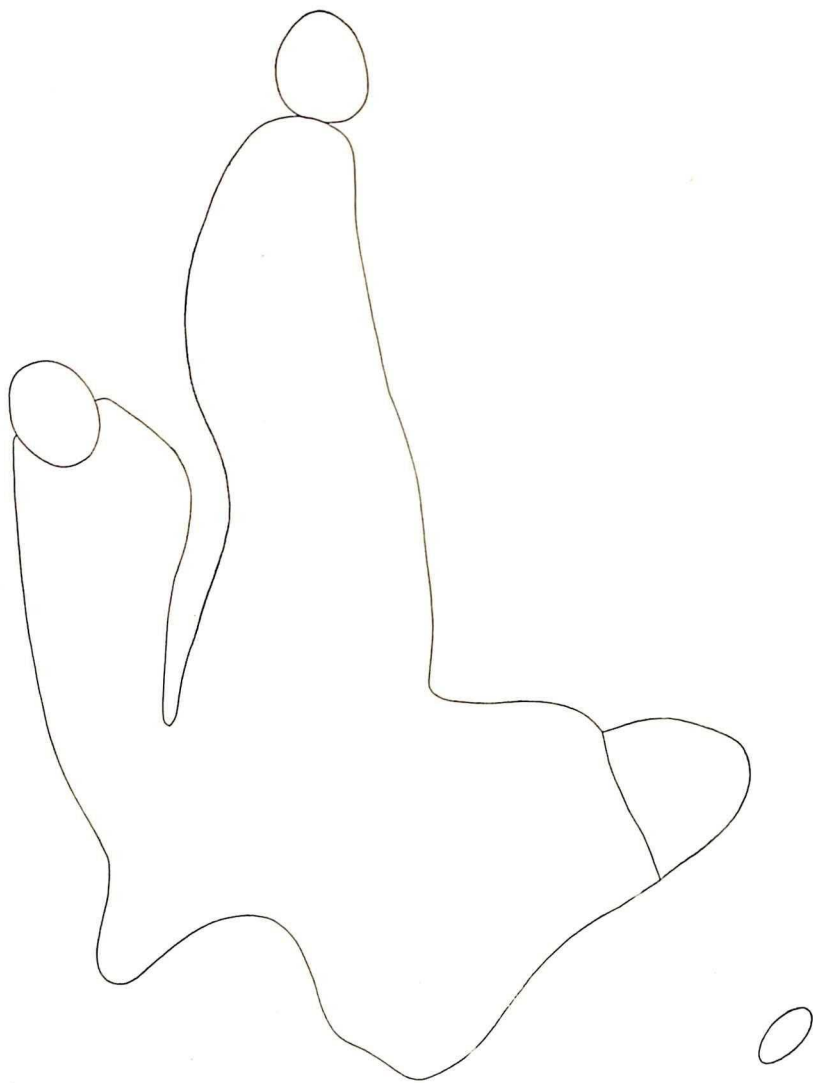


FIGURE 80.

Anticheiropus pilulatus Hitchcock, after Hitchcock, from the types Cat. Nos. 10/4 and 10/5 A.C. one-fourth natural size.

Specific Characters:—Pes: Length of digit II, 255 mm.; of III, 457 mm.; of IV, 315 mm.; of the foot, 520 mm.; between lateral tips, 420 mm. Extension of the middle digit beyond the others, 247 mm. Divergation of digits II and III, 75°; of III and IV, 15°; of the lateral digits, II and IV, 90°.

Imprint of the hallux claw, more or less elliptical in shape, lies about 90 mm. behind and within (mesad) that of digit II.

Locality:—Dexter Marsh's quarry in southwest Montague, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—This huge footprint may be somewhat distorted or otherwise abnormal, or it was made by a strangely aberrant form.

Anticheiropus pilulatus differs from *A. hamatus* not only in size, but in the bifid heel and the reversal of the offset digit plan. Here it is digit II, in *hamatus* it is digit IV, which is widely divergent from digit III.

As the footprint is isolated, no conception of the trackway pattern is possible, for neither pace nor width of trackway are recorded. Further material is essential to a complete understanding of this gigantic form.

Genus *Polemarchus* E. Hitchcock.

E. Hitchcock 1845, p. 24; 1848, p. 197; 1858, p. 107.

Lull 1904A, p. 520; 1915, p. 235.

Generic Characters:—Bipedal. Manus unknown. Pes: Tetradactyl, plantigrade, with a broad rounded heel and a large hallux extending at right angles to the axis of the foot (half rotated). Toes slender in the track, their true character being obscured by the apparent slumping of the sediment in the few specimens known, accordingly neither phalangeal pads nor claws are in evidence.

Discussion:—This track genus resembles *Eupalamopus dananus* most closely and was evidently made by a comparable reptile.

But one rare species has been described, *Polemarchus polemarchius*, which is therefore the genotype.

Polemarchus polemarchius (E. Hitchcock)

Sauroidichnites polemarchius E. Hitchcock 1841, p. 483, pl. 35, fig. 17.

Polemarchus gigas E. Hitchcock 1845, p. 24; 1848, p. 197, pl. 9, fig. 1; 1858, p. 107, pl. 18, fig. 1; pl. 59, fig. 3.

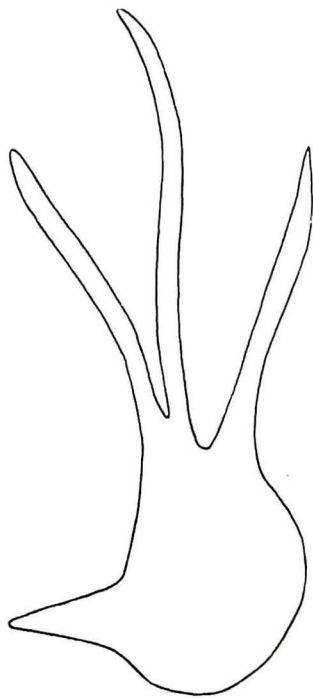


FIGURE 81.
Polemarchus polemarchius
(Hitchcock) after Hitchcock,
from the type Cat. No. 26/18 A.C.
one-fourth natural size.

Polemarchus gigas Lull, 1904A, p. 520.

Polemarchus polemarchius Lull 1915, p. 235, fig. 90.

Cotypes.—Cat. Nos. 26/15, 26/16 A. C., on slightly calcareous shale, from Chicopee Falls, and No. 26/17, from near Cabotsville, Mass. Nearby localities.

Specific Characters.—Pes: Huge, tetradactyl, plantigrade; large rounded heel and slender, inwardly curved digits except the hallux which is broad and acuminate, arising behind the middle of the heel and jutting at right angles to the axis of the foot. Length of digit I, 63 mm.; of II, 215 mm.; of III, 283 mm.; of IV, 210 mm. Projection of digit III beyond the others, 80 mm.; between lateral tips, 167 to 221 mm. Length of the foot, 374 mm.; of the heel, 95.5 mm.; its breadth, 98 mm. Divarication of digits II and III, 20°; of III and IV, 25°; of the lateral digits, II and IV, 45°; of I and III, 80°.

Length of the step, ?1,218 mm.; width of trackway, ? 304 mm. Ratio of foot to step, as 1 to 3.25.

Localities.—Chicopee Falls and Cabotsville, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion.—These remarkable footprints are very rare and the sediment seems to have slumped in so that the forward toes do not show their true character for they evidently are far too slender in the track.

Genus *Sillimanius* E. Hitchcock

(In honor of Professor Benjamin Silliman)

E. Hitchcock 1845, p. 24 (name but no description).

Ornithopus E. Hitchcock 1848, p. 191; 1858, p. 87.

Sillimanius Lull 1904A, p. 522; 1915, p. 226.

In 1845 (p. 24), Hitchcock published a synopsis of the Ichnozoa without descriptions, and



FIGURE 82.
Sillimanius
trackway, original,
one-fourth natural size.

the name *Sillimanius* among others appears therein. In 1848 this was followed by descriptions of the forms thus enumerated but, in several instances, with a change of name. Among them *Ornithopus* was substituted for *Sillimanius*.

In 1902, p. 551, O. P. Hay writes as follows:

"Originally four species, *S. adamsanus*, *S. tetradactylus*, *S. gracilior*, and *S. rogersianus* were assigned to this genus. The last named belongs under *Palamopus*. Later (1848) Hitchcock referred the first three species to *Ornithopus*, a new genus. As *Sillimanius* was based on described and figured forms, *Ornithopus* becomes a synonym."

Generic Description:—Small, bipedal, tetradactyl, digitigrade to semi-plantigrade. Hallux rotated to the rear so as to be in line with the fourth digit. Digits slender, without phalangeal pads or distinct claws.

Genotype:—*Sillimanius tetradactylus*.

But two species are now referred to this genus, the other being *S. gracilior*.

***Sillimanius tetradactylus* E. Hitchcock**

Ornithichnites tetradactylus E. Hitchcock 1836, p. 323, fig.

Ornithoidichnites tetradactylus E. Hitchcock 1841, p. 497, pl. 46, fig. 42.

Sillimanius tetradactylus E. Hitchcock 1845, p. 24.

Ornithopus gallinaceous E. Hitchcock 1848, p. 192, pl. 8, fig. 1; 1858, p. 87, pl. 14, fig. 10; pl. 58, fig. 1.

Lull 1904A, p. 522; 1915, p. 237, fig. 92.

Holotype:—Cat. No. 32/41, A. C., on red shale, from Wethersfield, Conn.

Specific Characters:—Pes: Length of digit I, 43 mm.; of II, 43 mm.; of III, 76 mm.; of IV, 51 mm.; projection of digit III beyond the others, 37 mm.; length of the foot, 97 mm.; between the lateral tips, 69 mm. Divarication of digits I and II, 110°; of II and III, 35°; of III and IV, 45°; of the lateral digits, II and IV, 80°.

Length of pace, 178 mm. Width of trackway, 64 mm. Ratio of foot to pace, as 1 to 1.83.

Pes angle, nearly 0°.

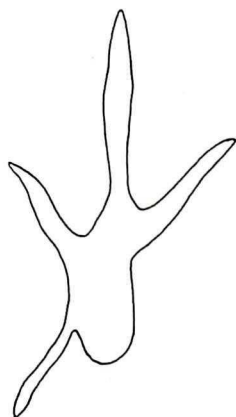


FIGURE 83.
Sillimanius tetradactylus
Hitchcock after Lull,
from Cat. No. 32/40 A. C.
one-half natural size.

Localities:—Turners Falls, Horse Race in Gill and near Cabotsville, Mass.; Wethersfield and Wethersfield Cove, Conn.

Geological Distribution:—Upper (Portland) series.

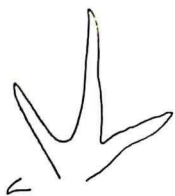


FIGURE 84.
Sillimanianus gracilior
Hitchcock, after
Hitchcock, from the
type Cat. No. 31/75 A.C.
one-half natural size.

***Sillimanianus gracilior* E. Hitchcock**

Ornithoidichnites gracilior E. Hitchcock
1841, p. 498, pl. 46, fig. 43.

Sillimanianus gracilior E. Hitchcock 1845,
p. 24.

Ornithopus gracilior E. Hitchcock 1848, p.
193, pl. 8, fig. 2; 1858, p. 88, pl. 14, fig. 11; pl.
58, fig. 7.

Lull 1904A, p. 523; 1915, p. 237, fig. 93.

Holotype:—Cat. No. 31/75, A. C., on red
shale from Wethersfield, Conn.

Specific Characters:—Pes: Length of digit I, 10 mm.; of II, 21 mm.; of III, 32 mm.; of IV, 23 mm. Projection of digit III beyond the others, 17 mm. Length of the foot, 43 mm.; between lateral tips, 43 mm.

Divarication of digits I and II, 85°; of II and III, 35°; of III and IV, 52°; between lateral digits, II and IV, 85° to 90°.

Length of pace, 153 mm.; width of trackway, 115 mm. Ratio of foot to pace, as 1 to 3.56.

Pes angle, nearly 0°. Pace angle, 160° or more.

Localities:—Turners Falls, north bank below Turners Falls (Gill), Mass. Wethersfield and Wethersfield Cove, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion: *Sillimanianus gracilior* differs from *S. tetradactylus* chiefly in its smaller size, relatively shorter pace, absence of heel impression, and less divarication of digits I and II.

Genus *Eupalamopus* Hay

O. P. Hay, 1902, p. 544.

Name given by Hay as a substitute for *Palamopus* preoccupied by Hitchcock in 1848, p. 217.

Lull 1904A, p. 531; 1915, p. 250.

Generic Characters:—Bipedal in gait, occasionally quadrupedal. Pes: tetradactyl, plantigrade, with a broad rounded heel. Three digits directed forward, hallux variable in direction from obliquely forward to one at right angles with the axis of the foot. Digits rather slender,

acuminate, without phalangeal pads or distinct claws. The inner and middle toes curved inward. Manus outline vague, but apparently about one-third the length of the pes.

But one species, *Eupalamopus dananus*, is known, which is therefore the genotype.

Discussion:—*Eupalamopus* is so suggestive of *Polemarchus* that the two may be generically synonymous, for the more slender, "lithy" digits of the latter may be due to the character of the sediment which slumped in with the withdrawal of the foot in the only known specimens. Should the two genera prove to be synonymous the name *Polemarchus* has priority.



FIGURE 85.
Eupalamopus
trackway, original.
one-eighth natural size.

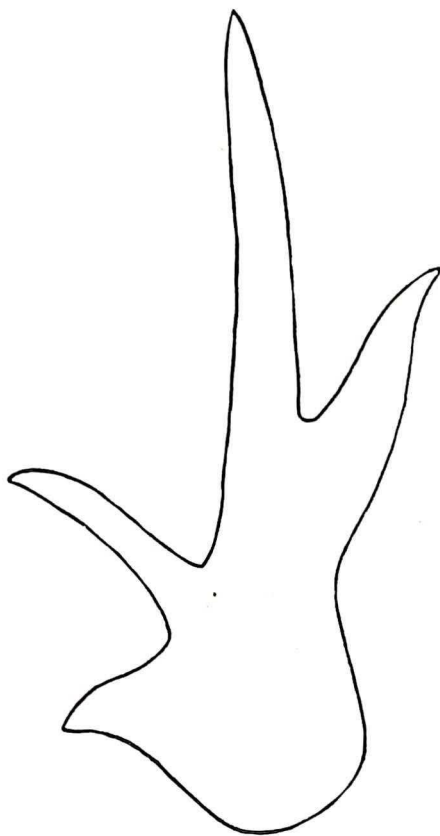


FIGURE 86.
Eupalamopus dananus (Hitchcock) after Lull.
from Cat. No. 12/1 A. C. one-half natural size.

Eupalamopus dananus (E. Hitchcock)

Palamopus dananus E. Hitchcock 1848, p. 217, pl. 11, figs. 1, 2.

*Palamopus clarki*¹ E. Hitchcock 1858, p. 127, pl. 23, fig. 2; pl. 44, fig. 2.

Lull, 1904A, p. 531; 1915, p. 250, fig. 108.

Holotype:—Cat. No. 12/1, A. C., on a slab of gray sandstone with two depressed pes tracks of *E. dananus* and probably a manus imprint half way between them. From the east foot of Mount Tom, Mass. Unique.

Specific Characters:—Manus: Length, 90 mm.; width, 38 mm. Characters highly obscure.

Pes: Length of digits measured from their base. Of I, 50 to 30 mm.; of II, 65 mm.; of III, 118 to 142 mm.; of IV, 55 mm. Projection of digit III beyond the others, 68 to 85 mm. Length of the foot, 215 mm.; of the heel, 93 to 70 mm.; its breadth, 50 to 56 mm.; between lateral tips, 118 to 123 mm. Divarication of digits I and II, 25° to 45°; of II and III, 30° to 47°; of III and IV, 15° to 33°; of the lateral digits, II and IV 67° to 76°.

Length of the pace, 535 mm.; width of the trackway, 126 mm. Ratio of foot to pace, as 1 to 2.5.

Pes angle, nearly 0°.

The measurements given are those of the two successive tracks of the same animal; those given first are taken from the left rear track and the second from the right forward one.

Locality:—Mount Tom East, Massachusetts.

Geological Distribution:—Upper (posterior) shales (Meriden series).

Group VII. Bipedal forms without manus impression. Tridactyl or tetradactyl. Semi-digitigrade to plantigrade. Pace moderate; trackway medium to wide.

Genera: *Platypterna*, *Argoides*, *Steropoides*, *Trihamus*.

Genus *Platypterna* E. Hitchcock

E. Hitchcock 1845, p. 28; 1858, p. 83.

Lull 1904A, p. 515; 1915, p. 227.

Generic Characters:—Apparently bipedal, tridactyl, plantigrade or calcigrade, generally with a broad, flat, rounded heel; hence the name. Digits slender and curved, without phalangeal pads and but rarely showing distinct claws.

¹This is one of several instances in which Hitchcock gave a new name which he considered more appropriate, to an already described species. Of course the original name has priority.

Discussion.—Distinguished from *Argoides* which it resembles, chiefly by the broad heel.

Seven species of *Platypterna* have been described; *P. deanii*, *concamerata*, *recta*, *digitigrada*, *delicatula*, *tenuis*, and *gracillima*; of which *P. deanii* is the genotype.

***Platypterna deanii* (E. Hitchcock)**

Ornithoidichnites deanii E. Hitchcock 1841, p. 493, pl. 42, figs. 31, 32.

Platypterna deanianus E. Hitchcock 1845, p. 25.

Platypterna deaniana E. Hitchcock 1848, p. 189, pl. 7, fig. 1; 1858, p. 83, pl. 14, fig. 4.

Lull 1904A, p. 516.

Platypterna deanii, Lull 1915, p. 227, fig. 78.

Holotype.—Cat. No. 32/26 A. C., on fine red shale from Wethersfield, Conn.



FIGURE 87.
Platypterna trackway, original
one-fourth natural size.



FIGURE 88.
Platypterna deanii
(Hitchcock), after Lull,
from the type Cat.
No. 32/26 A. C.
one-half natural size.

Specific Characters.—Pes: Length of digit II, 50 mm.; of III, 76 mm.; of IV, 38 mm.; length of heel, 30 mm.; its breadth, 23 mm. Length of the foot, 100 to 115 mm.; between lateral tips, 51 to 63 mm. Projection of digit III, beyond the others, 42 to 48 mm. Divarication of digits II and III, 25° to 30° ; of III and IV, 40° to 45° ; of the lateral digits, II and IV, 60° to 70° .

Length of stride, 228 to 304 mm.; from Cat. No. 32/29 A. C. with two tracks. Width of trackway 138–150 mm. Ratio of foot to stride, as 1 to 2.28.

Pes angle, 10° inward.

Localities.—Wethersfield, Wethersfield Cove, Conn., and Turners Falls, Mass.

Geological Distribution.—Upper (Portland) series.

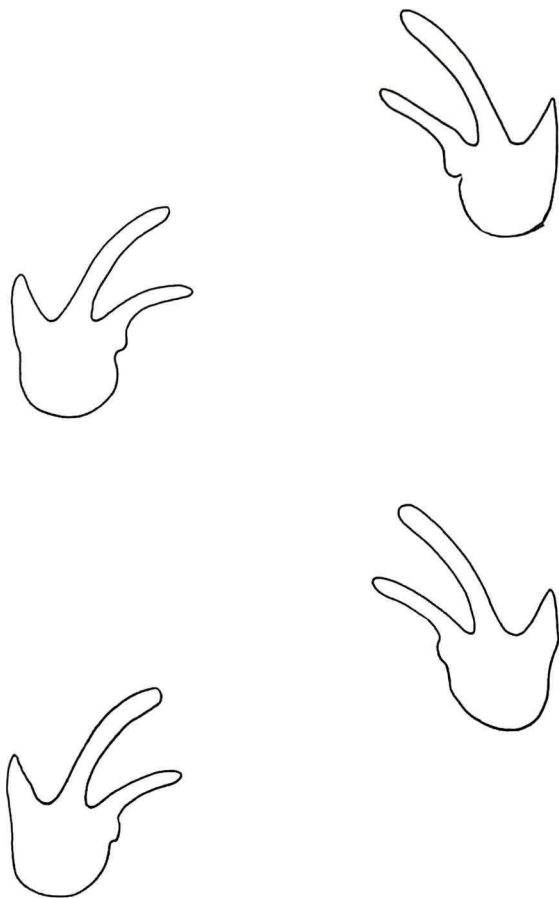


FIGURE 89.
Platypterna concamerata trackway, original, one-fourth natural size.

Platypterna concamerata
(E. Hitchcock)

Harpedactylus concameratus
E. Hitchcock 1848, p. 207, pl. 14,
fig. 3.

Platypterna varica E. Hitch-
cock 1858, p. 85, pl. 14, fig. 8; pl.
47, fig. 4.

Lull, 1904A, p. 516; 1915, p.
227, fig. 79.

Holotype:—Cat. No. 11/1, A.C.,
on gray micaceous sandstone from
Turners Falls, Mass.

Specific Characters:—*Pes*:
Length of digit II measured from
the middle of the heel, 76 mm.;
of III, 90 mm.; of IV, 50 mm.;
length of the heel, 28 mm.; its
breadth 50 mm. Length of the foot, 127 mm.; between lateral tips, 94
mm. Projection of digit III beyond the others, 50 mm. Divarication
of digits II and III, 23°; of III and IV, 52°; of the lateral digits II and
IV, 75°.

Length of the stride, 200–300 mm. Width of the trackway, 280
mm. Ratio of foot to average stride, as 1 to 2.

Pes angle, 20° inward.

Interpes length to middle of heel, 252 mm.

Pace angle 55°.

Localities:—Ferry at Turners Falls and Gill, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Platypterna concamerata* is remarkable for the great
width of the heel, and the inward curvature of the toes, all of which
have bluntly rounded extremities except the fourth which is pointed.
The very wide straddle of the feet in walking implies a short-legged,
wide-bodied form.

Platypterna digitigrada E. Hitchcock

E. Hitchcock 1858, p. 86, pl. 14, fig. 9; pl. 51, fig. 2.

Lull 1904A, p. 516; 1915, p. 228, fig. 80.

Holotype:—Cat. No. 36/16 A.C., on two leaves of shale with five
tracks of *P. digitigrada* and other forms. From Turners Falls, Mass.

Specific Characters:—*Pes*: Length of digit II, 20 mm.; of III, 30 mm.;

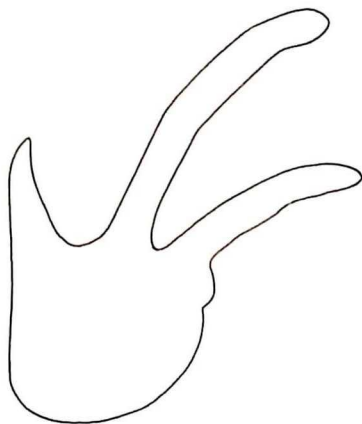


FIGURE 90.

Platypterna concamerata (Hitchcock)
after Hitchcock, from the type Cat.
No. 11/1 A.C. one-half natural size.



FIGURE 91.
Platypterna digitigrada
Hitchcock, after Hitchcock,
from Cat. No. 36/16 A.C.
one-half natural size.

of IV, 23 mm. Projection of digit III beyond the others, 14.5 mm. Length of the foot, 50 mm.; between lateral tips, 40 mm. Divarication of digits II and III, 43°; of III and IV, 37°; of the lateral digits, II and IV, 80°.

Inner and middle toes curve inward and are thick, with acuminate claws.

Length of stride, 100 to 115 mm.; width of trackway, 76 mm. Width of the heel, 20 mm. Ratio of foot to stride, as 1 to 2.

Pes angle, 10° to 20° inward.

Interpes distance from axis of foot to median line, 15 mm.; to opposite foot, 30 mm.

Localities:—Field's orchard, Lily Pond, Gill, and Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Platypterna tenuis (E. Hitchcock)

Ornithoidichnites tenuis E. Hitchcock 1841, p. 494, pl. 43, figs. 33, 34.

E. Hitchcock 1845, p. 25; 1848, p. 189, pl. 7, figs. 2, 3; 1858, p. 84, pl. 14, fig. 5; pl. 58, fig. 10.

Lull 1914A, p. 517; 1915, p. 229, fig. 81.

Holotype:—Cat. No. 32/38 A. C. Four tracks on red shale from Wethersfield, Conn.

Specific Characters:—Pes: Length of digit II, 25 mm.; of III, 42 mm.; of IV, 35 mm.; breadth of heel, 15 mm. Length of foot, 69 mm.; between lateral tips, 48 mm. Projection of digit III beyond the others, 22-27 mm. Divarication of digits II and III, 20° to 30°; of III and IV, 25° to 30°; of the lateral digits, II and IV, 45° to 60°.

Length of the stride, 178 mm.; width of trackway, 50 mm. Ratio of foot to stride, as 1: 2.57.

A relatively long-limbed, semi-plantigrade form whose entire heel does not impress.

Locality:—Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.



FIGURE 92.
Platypterna tenuis
(Hitchcock), after Hitchcock,
from the type Cat.
No. 32/38 A. C.
one-half natural size.

Platypterna delicatula (E. Hitchcock)

Ornithichnites delicatulus E. Hitchcock
1841, p. 497, pl. 45, fig. 40.

Calopus delicatulus E. Hitchcock 1845,
p. 25.

E. Hitchcock, 1848, p. 190, pl. 7, fig. 4;
1858, p. 84, pl. 14, fig. 6; pl. 58, fig. 8.

Lull 1904A, p. 517; 1915, p. 229, fig. 82.

Holotype:—Cat. No. 31/11 A.C. On red
shale from Wethersfield Cove, Conn.

Specific Characters:—Pes: Length of digit II, 17 mm.; of III, 28 mm.; of IV, 19 mm.; of the foot, 37 mm.; between lateral tips, 15 mm. Projection of digit III beyond the others, 12 mm. Length of heel, 10 mm.; its breadth, 85 mm. Divarication of digits II and III, 22°; of III and IV, 18°; of the lateral digits, II and IV, 40°.

Length of pace, 76 mm.; width of trackway, 50 mm. Ratio of foot to pace, as 1 to 2.06.

Pes angle, 18° to 28°. Pace angle, 128°. Interpes distance 30 mm.

Localities:—Lily Pond, Ferry at Gill, Turners Falls, Mass. Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Platypterna delicatula* is the smallest species of the genus.



FIGURE 93.

Platypterna delicatula
(Hitchcock)
after Hitchcock,
from the type
Cat. No. 31/11
one-half natural size.

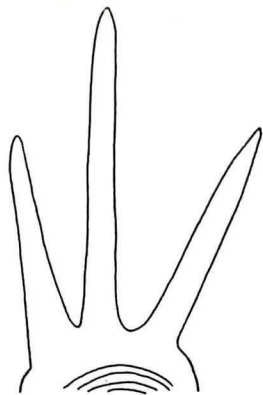


FIGURE 94.

Platypterna recta (Hitchcock)
after Hitchcock, from the
type Cat. No. 6/2 A.C.
one-half natural size.

Platypterna recta (E. Hitchcock)

E. Hitchcock 1858, p. 84, pl. 14, fig.
7; pl. 47, fig. 3.

Harpedactylus rectus E. Hitchcock
1848, p. 209, pl. 5, fig. 5; pl. 24, fig. 7.

Lull 1904A, p. 518; 1915, p. 230,
fig. 83.

Holotype:—Cat. No. 6/2 A.C., on hard
argillaceous sandstone, from Gill, Mass.

Specific Characters:—Pes: Length of digit II, 55 mm.; of III, 80 mm.; of IV, 60 mm.; of the foot, 95 mm.; between lateral tips, 63 mm.; breadth of heel 45 mm. Divarication of digits II and III, 10°; of III and IV, 27°; of the lateral digits II and IV, 36°.

Length of stride, 140 mm.; width of trackway, 140 mm. Ratio of foot to stride, as 1 to 1.47.

Pes angle, 5° to 10° , inward.

Interpes distance, 88 mm.

Locality:—Gill, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—The heel of this form is only partly impressed so that the total length of the foot is unrecorded. The digits are straight, thus differing markedly from both *deanii* and *concamerata*, but in the short legs and wide body *P. recta* resembles the latter species most closely. These three species are evidently closely allied and as such are quite distinct from the three other species of *Platypterna*.

Genus *Trihamus* E. Hitchcock

E. Hitchcock 1865, p. 9.

Lull 1904A, p. 542.

Generic Description:—Small, bipedal, tridactyl, plantigrade forms. Digits slender, curved inward, hook-like; heel large.

Two species have been described: *Trihamus elegans* E. Hitchcock, the genotype, and *T. magnus* C. H. Hitchcock.

Trihamus elegans E. Hitchcock

E. Hitchcock 1865, p. 9, pl. 2, fig. 3.

Lull 1904A, p. 542.

Holotype:—Cat. No. 47/30 A. C., from Turners Falls, Mass. But two steps. No other specimen in Amherst Collection.

Specific Characters:—Pes: Length of digit II, 15 mm.; of III, 18.5 mm.; of IV, 22 mm.; of the foot, 29 mm.; between lateral tips, 20 to 23 mm. Length of the heel, 7 to 12 mm.; its breadth, 10 to 12 mm. Divarication of digits II and III, 43° ; of III and IV, 20° ; of the lateral digits II and IV, 70° to 80° .

Length of pace, 130 mm. Ratio of foot to pace, as 1 to 4.5.

Pes angulation, 20° inward. Pace angulation, 150° to 160° .

Localities:—Turners Falls and Gill, Mass.

Geological Distribution:—Upper (Portland) series.

Trihamus magnus C. H. Hitchcock

C. H. Hitchcock 1889, p. 118, 126.

Lull 1904A, p. 542.

Holotype:—Mt. Holyoke College collection [Cat. Nos. 32 and 274?]. Wethersfield, Conn. Destroyed by fire. Y. P. M. Cat. No. 3476. Counterparts. Two left pes imprints, from the Ferry, Gill, Mass.

Specific Characters:—C. H. Hitchcock's description is very meager. It reads: "Very like *T. elegans* save in size. Length of the step about 6 inches"=[152 mm].

The Peabody Museum contains a specimen, Cat. No. 3476, counterparts, bearing two pes imprints from the Ferry at Gill which agree more or less with Hitchcock's description as far as it goes. Dimensions are: Length of digit II, 28 mm.; of III, 48 mm.; of IV, 40 mm.; of the foot, 78 mm.; between the lateral tips, 48 mm. Divergation of digits II and III, 14°; of III and IV, 39°; of the lateral digits, II and IV, 54°. Length of the stride of the same foot, 143 mm. of the pace, 72 mm.

Locality:—Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion:—The locality of this specimen is far removed from that of the type and the identity of the species is open to question. If it is disproved, *Trihamus magnus* becomes a *nomen nudum*.

Genus *Argoides* E. Hitchcock

E. Hitchcock 1845, p. 24.

Argozoum E. Hitchcock 1848, pp. 184-185; 1858, p. 81.

Lull, 1904A, p. 518; 1915, p. 230.

Generic Characters:—Small bipedal forms; tridactyl and digitigrade. Digits of the footprint narrow (leptodactylous) without distinct claws or phalangeal pads. Toes more or less curved; the lateral ones outward; somewhat keel-shaped; the track rarely showing a heel, and never a tail trace.

A number of species of *Argoides* (seven or more) have been described, some of which are apparently synonymous. They are now reduced to three: *Argoides minimus*, *A. macrodactylus*, and *A. redfieldii*, of which *A. minimus* is the genotype.



FIGURE 95.
Trihamus elegans
Hitchcock,
after Hitchcock,
corrected from the
type Cat. No. 47/30
A. C. natural size.



FIGURE 96.

Argoides minimus
(Hitchcock),
after Hitchcock,
(from Cat. No. 23/1?)
one-half natural size.

Argoides minimus (E. Hitchcock)

Ornithichnites minimus E. Hitchcock 1836, p. 325, fig. 9.

Ornithoidichnites isodactylus (in part) E. Hitchcock 1841, p. 496, pl. 45, figs. 38-39.

Ornithoidichnites minimus (in part) E. Hitchcock 1841, p. 496, pl. 45, fig. 41.

Argoides isodactylus E. Hitchcock 1845, p. 24.

Argoides minimus E. Hitchcock 1845, p. 24 (in part).

Argozoum pari-digitatum E. Hitchcock 1845, p. 187, pl. 6, figs. 3-4; 1858, p. 82, pl. 14, fig. 3; pl. 35, fig. 4; pl. 39, fig. 1.

Argozoum minimum E. Hitchcock 1848, p. 187, pl. 6, fig. 5.

? *Plesiornis aequalipes* E. Hitchcock 1858, p. 105, text fig. (in part).

Argoides isodactylus Lull, 1904A, p. 518.

Lull 1915, p. 230, fig. 84.

Holotype:—Cat. No. 25/1 A. C., on red shale, from the Lily Pond, Gill, Mass.

Specific Characters:—Pes: Length of digit II, 23 mm.; of III, 33 mm.; of IV, 25 mm. Projection of digit III beyond the lateral toes, 25 mm. Length of the foot, 44 mm.; between lateral tips, 42 mm. Divergation of digits II and III, 40°–50°; of III and IV, 40°–50°; of the lateral digits, II and IV, 80°–100°.

Length of pace, 152 mm.; width of trackway, 43 mm. Ratio of foot to pace, as 1 to 3.45. Pes angulation 10°.

Localities:—Lily Pond, Horse Race, Gill, Turners Falls, Massachusetts. Wethersfield, Conn. (for *Plesiornis aequalipes* type, evidently a synonymous form). *red shale*

Geological Distribution:—Upper (Portland) series.

Discussion:—The original *O. minimus* of 1836 was renamed *isodactylus* in 1841 and the name *minimus* applied to a smaller form. If the smaller form is a new species, the name *minimus* cannot be applied to it. But merely dimensional distinction alone is not sufficient to warrant a new name.

Argoides macrodactylus
(E. Hitchcock)

Ornithoidichnites macrodactylus E. Hitchcock 1841, p. 494, pl. 43, fig. 35.

Platypterna macrodactylus (E. Hitchcock) 1845, p. 25.

Argozoum dispari-digitatum E. Hitchcock 1848, p. 186, pl. 6, fig. 2; 1858, p. 82, pl. 14, fig. 2.

Lull, 1904A, p. 519; 1915, p. 231, fig. 85.

Holotype:—Cat. No. 37/17 A. C., from Wethersfield, Conn.

Specific Characters:—*Pes*: Length of digit II, 76 mm.; of III, 127 mm.; of IV, 90 mm.; projection of digit III beyond the lateral toes, 45 to 63 mm.; length of foot, 140 mm.; between lateral tips, 76 mm. Divarication of digits II and III, 18° to 30°; of III and IV, 20° to 25°; of the lateral digits, II and IV, 40° to 55°.

Length of step, 380 mm.; width of trackway, 100 mm. Ratio of foot to step, as 1 to 2.13.

Pes angle, 0°.

Localities:—Turners Falls and Chicopee, Mass.; Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Argoides redfieldii (E. Hitchcock)

Ornithoidichnites redfieldii E. Hitchcock 1844, p. 304, pl. 3, fig. 1.

Argoides redfieldianus E. Hitchcock 1845, p. 24.

Argozoum redfieldianum, E. Hitchcock 1848, p. 185, pl. 6, fig. 1; 1858, p. 81, pl. 14, fig. 1.

Argoides redfieldianus, Lull 1904A, p. 519.

Argoides redfieldii Lull 1915, p. 232.

Cotypes:—Cat. Nos. 14/2, 14/3 A. C. On hard, gray, thick-bedded sandstone from Chicopee Falls, Mass.

Specific Characters:—*Pes*: Length of digit II, 203 mm.; of III, 304 mm.; of IV, 240 mm.; Projection of digit III beyond the lateral toes,

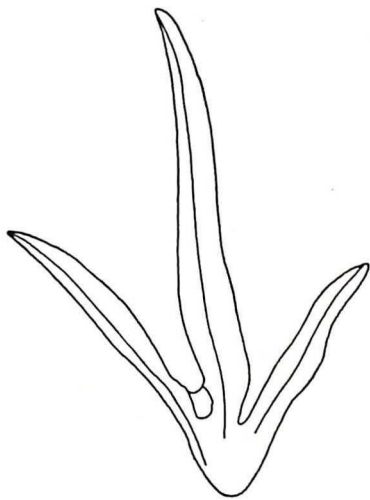


FIGURE 97.
Argoides macrodactylus (Hitchcock)
after Lull, one-half natural size.

153 mm. Length of foot, 315 mm.; between lateral claws, 305 mm. Divarication of digits II and III, 30° ; of III and IV, 45° ; of the lateral digits, II and IV, 75° .

Length of step, 762 mm. Width of trackway, 325 mm. Ratio of foot to step, as 1 to 2.4.

Pace angulation, 0° to 10° .

Discussion:—This is a large track, but with relatively very slender digits. In size and divarication of digits it approximates *Eubrontes divaricatus* and may be a slumped-in track of that species.

It had a coprolite associated with it which on analysis showed the presence of uric acid which seems to point to the Sauropsida, but not necessarily to a bird as Hitchcock thought.

Locality:—Chicopee Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Genus *Steropoides*

E. Hitchcock

E. Hitchcock 1845, p. 24.

Steropezoum E. Hitchcock
1848, p. 182.

Tridentipes E. Hitchcock
1858, p. 82 (to replace *Steropezoum*).

Lull 1904A, p. 523; 1915,
p. 238.

Generic Characters:—Bipedal, tetradactyl, sub-digitigrade to semi-plantigrade. Tarsus sloping upward so that the impression often ends in ridges and furrows formed in the mud when the foot is raised. The hallux is rotated backward so as to lie generally in line with digit IV.

Five species have been described, as follows:

S. diversus, *ingens*, *divaricatus*, *uncus*, all of E. Hitchcock; *S. infelix* Hay, to replace *elegantior*, a name already used within the genus.

No genotype has been assigned, but *Steropoides diversus* may be taken as such.

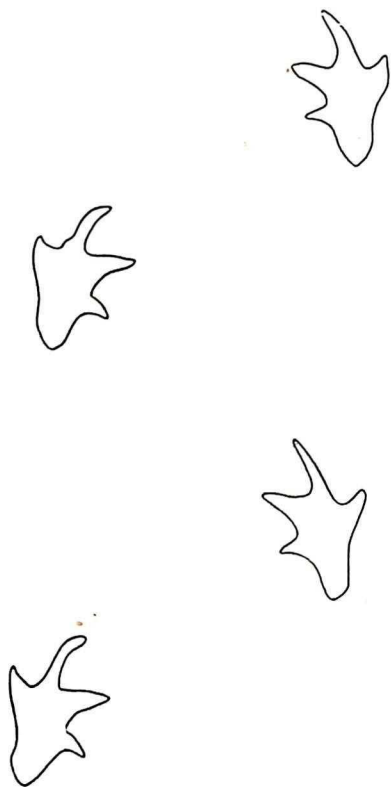


FIGURE 98.

Steropoides uncus trackway, original,
one-fourth natural size.

Steropoides diversus (E. Hitchcock)

Ornithichnites diversus E. Hitchcock 1836, fig. 22.

Ornithoidichnites elegans E. Hitchcock 1841, p. 491, pl. 41, figs. 28, 29.

Ornithoidichnites elegantior E. Hitchcock 1841, p. 493, pl. 42, fig. 30.

Steropoides elegans E. Hitchcock 1845, p. 24.

Steropoides elegantior E. Hitchcock 1845, p. 24.

Steropezoum elegans E. Hitchcock 1848, p. 183, pl. 5, fig. 2.

Steropezoum elegantius E. Hitchcock 1848, p. 184, pl. 5, fig. 3.

Tridentipes elegans E. Hitchcock 1858, p. 90, pl. 15, fig. 2; pl. 45, fig. 6; pl. 52, figs. 8, 11.

Steropoides elegans Lull 1904A, p. 523.

Steropoides diversus Lull 1915, p. 238, fig. 94.

Holotype:—Cat. No. 26/21 A. C., on red shale from Turners Falls.

Specific Characters:—Pes: Length of digit I, 46 mm.; of II, 46 mm.; of III, 71 mm.; of IV, 56 mm.; between lateral tips, 89 mm.; of the foot impression, 135 mm.; length of heel impression, 64 mm.; its breadth, 13 mm. Divarication of digits I and II, 75°; of II and III, 65°; of III and IV, 65°; of the lateral digits, II and IV, 125°.

Length of pace, 250 mm.; of the stride, 500 mm. Width of trackway, 178 mm. Ratio of foot to pace, as 1 to 1.85.

Pes angle, 0° to 10°.

Interpes distance between the heels, 100 mm.

Localities:—Horse Race, Lily Pond, Turners Falls, Montague City, Mass.; Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Steropoides ingens (E. Hitchcock)

Ornithichnites ingens E. Hitchcock 1836, p. 319, fig.

Ornithoidichnites ingens E. Hitchcock 1841, p. 490, pl. 40, fig. 27.

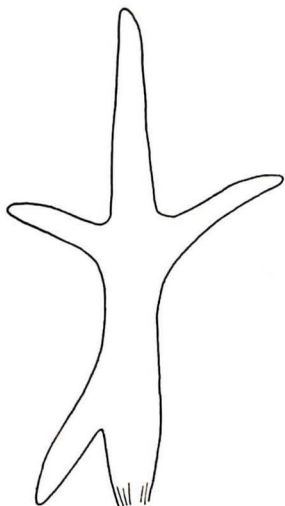


FIGURE 99.

Steropoides diversus (Hitchcock) after Hitchcock, from the type Cat. No. 26/21 A. C. one-half natural size.

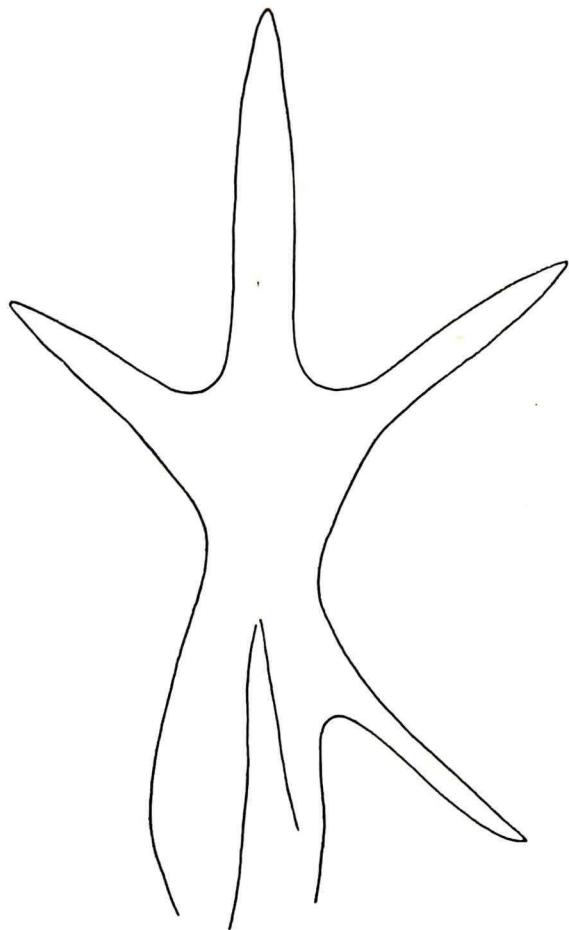


FIGURE 100.

Steropoides ingens (Hitchcock), after Lull, from the type
Cat. No. 16/12 A. C. one-fourth natural size.

Ornithoidichnites danae E. Hitchcock 1844, p. 306, pl. 5, fig. 1.

Sillimanius adamsanus E. Hitchcock 1845, p. 24.

Steropoides ingens E. Hitchcock 1845, p. 24.

Steropezoum ingens E. Hitchcock 1848, p. 182, pl. 15, fig. 1.

Ornithopus adamsanus E. Hitchcock 1848, p. 191, pl. 7, fig. 5.

Tridentipes ingens E. Hitchcock 1858, p. 89, pl. 15, fig. 1.

Lull 1904A, p. 524; 1915, p. 239, fig. 95.

Holotype:—Cat. No. 16/12 A. C., on gray micaceous sandstone from
Gill, Mass.

Specific Characters.—Huge, plantigrade, tetradactyl track without phalangeal or distinct claw impressions. Heel large with somewhat radiating ridges beneath its posterior part.

Pes: Length of digit I, 127 mm.; of II, 203 to 246 mm.; of III, 245 to 328 mm.; of IV, 146 to 260 mm.; projection of digit III beyond the others, 113 mm. Length of the foot, 460 to 635 mm.; between lateral tips, 240 to 282 mm. Divarication of digits I and II, 80°; of II and III, 35° to 50°; of III and IV, 23° to 58°; of the lateral digits, II and IV, 50° to 107°.

Length of step, 1020 to 2020 mm.

Ratio of average foot to average stride, as 1 to 2.77.

Localities.—Mt. Tom East, Horse Race, Gill, Mass.

Geological Distribution.—Upper (posterior) shales; Upper (Portland) series.

Steropoides infelix Hay

Tridentipes elegantior E. Hitchcock 1858, p. 90, pl. 15, fig. 3; pl. 45, fig. 1. (Not *Steropozoum elegantius* of 1848.)

Hay 1902, p. 550, new specific name to replace the name *elegantior* already used within the genus.

Lull 1904A, p. 524; 1915, p. 240, fig. 96.

Holotype.—Cat. No. 19/9 A. C., on reddish shale from Turners Falls, Mass.

Specific Characters.—*Pes*: Small, plantigrade, with rounded heel. Without phalangeal pads or distinct claws. Length of digit I, 10 mm.; of II, 15 mm.; of III, 25 to 29 mm.; of IV, 22 mm.; projection of digit III beyond the others, 14 mm.; length of heel, 17 mm. Length of foot, 45 mm. Between lateral tips, 28 mm. Divarication of digits I and II, 108°; of II and III, 32°; of III and IV, 44°; of the lateral digits, II and IV, 75°.

Length of the pace, 135 mm. Width of the trackway, 45 mm. Ratio of foot to pace, as 1 to 3.

Pes angle, 0°–10°.

Localities.—Lily Pond, Gill, Turners Falls, Mass., and Wethersfield, Conn.

Geological Distribution.—Upper (Portland) series.

Steropoides divaricatus (E. Hitchcock)

Ornithoidichnites divaricatus E. Hitchcock 1841, p. 495, pl. 44, fig. 36, 37.

Ornithopus loripes E. Hitchcock 1848, p. 193, pl. 8, fig. 3.



FIGURE 101.

Steropoides infelix
Hay, after Hitchcock
from the type Cat.
No. 19/9 A. C.
one-half natural size.

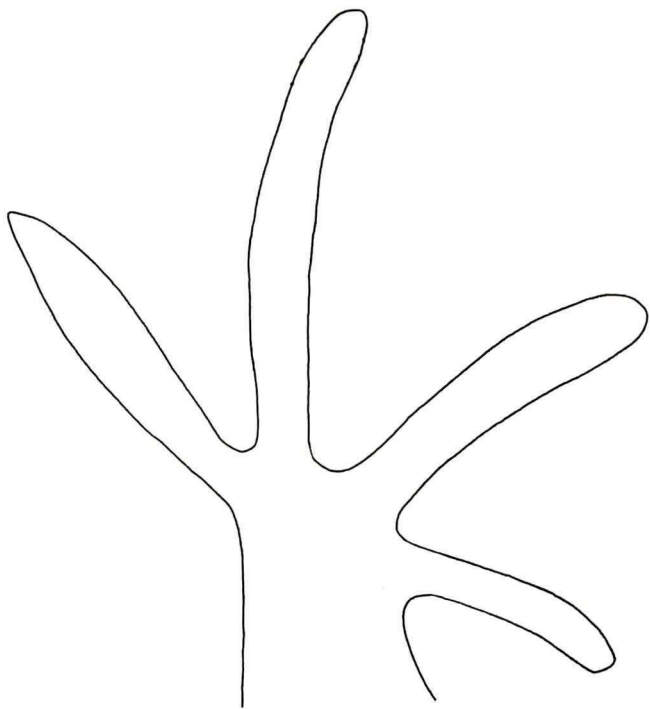


FIGURE 102.

Steropoides divaricatus (Hitchcock) after Hitchcock, from the types Cat. Nos. 1/4 and 5/11 A.C. one-half natural size.

Tridentipes insignis E. Hitchcock 1858, p. 91, pl. 15, fig. 4; pl. 45, fig. 3; pl. 47, fig. 2.

Steropoides loripes Lull 1904A, p. 525.

Steropoides divaricatus Lull 1915, p. 240, fig. 97.

Cotypes.—Cat. Nos. 1/4 A. C., on micaceous sandstone from Marsh's quarry; southwest part of Montague; and 5/ 11 A. C., on gray micaceous sandstone from below Smith's Ferry, Mass.

Specific Characters.—*Pes*: Large, tetradactyl, sub-plantigrade, with slender digits, without phalangeal pads or claws. Heel only partially impressed, widening toward the rear.

Length of digit I, 81 mm.; of II, 109 mm.; of III, 140 mm.; of IV, 109 mm. Projection of digit III beyond the other toes, 63 mm. Length of the foot, 152 to 178 mm. Between lateral tips, 160 mm. Divarication of digits I and II, 55°; of II and III, 45°; of III and IV, 50°; of the lateral digits, II and IV, 95°.

Length of the stride, 407 to 584 mm. Width of the trackway, 316 mm. Ratio of average foot to average stride, as 1 to 3.

Pes angle, 10° inward. Interpes distance (mid heel), 152 mm.

Localities:—Southwest part of Montague, Horse Race, Gill, Northampton, Chicopee, Mass., and Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Steropoides uncus (E. Hitchcock)

Tridentipes uncus E. Hitchcock 1858, p. 91, pl. 15, fig. 5; pl. 46, fig. 1.

Lull 1904A, p. 525; 1915, p. 243, fig. 98.

Holotype:—Cat. No. 6/1 A. C., from the Lily Pond, Gill, Mass.

Specific Characters:—Pes: plantigrade, hallux semi-rotated, digits all curved inward, but without phalangeal pads or distinct claws.

Length of digit I, 28 mm.; of II, 42 mm.; of III, 56 mm.; of IV, 36 mm. Projection of digit III beyond the lateral toes, 30 mm. Length of heel, 28 mm.; of the foot, 82 mm. Between lateral tips, 50 mm. Divarication of digits I and II, 22° ; of II and III, 48° ; of III and IV, 44° ; of the lateral digits, II and IV, 90° .

Length of the stride, 115 to 127 mm.; width of trackway, 88 mm. Ratio of foot to average stride, as 1 to 1.474.

Pes angle, 5° to 20° inward; interpes distance, center of heels, 75 mm.

Localities:—Lily Pond, Gill, and Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Steropoides uncus* differs markedly from other members of the genus in the short pace and wide trackway and in the semi-rotated hallux and complete heel on the track.

Group VIII. Quadrupedal, manus and pes tetradactyl. Digitigrade to semi-plantigrade. Pace generally long; trackway narrow, feet almost in line.

Genera: *Batrachopus*, *Cheirotheroides*, *Comptichnus*, *Shepardia*, (? *Antipus*).

Genus *Batrachopus* E. Hitchcock

E. Hitchcock 1845, p. 25.

Anisopus E. Hitchcock 1848, p. 226.

Anisichnus C. H. Hitchcock 1871, p. xxi (to replace *Anisopus* pre-occupied).

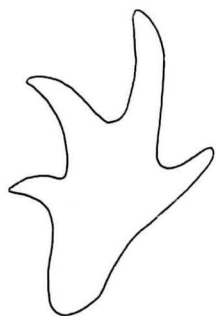


FIGURE 103.

Steropoides uncus
(Hitchcock) after Hitchcock,
from the type Cat. No.
6/1 A.C. one-half natural size

Lull 1904A, p. 482; 1915, p. 174.

Generic Characters:—Small quadrupedal forms. Manus probably with five digits, of which at least four always appear in the track. Digits broad, apparently clawless, generally directed forward. Pes four-toed; hallux non-rotated, digits with slender, acuminate claws, that of the fourth, however, may be absent in the impression, possibly also in the foot. Manus and pes imprints close together, generally in a right line.

Five species of the genus *Batrachopus* are now recognized: *B. bellus*, *B. deweyi*, *B. dispar*, *B. gracilior*, and *B. gracilis*, of which *B. deweyi* is the genotype.

Discussion:—In 1845, in the Proceedings of the Sixth Annual Meeting of the Association of American Geologists and Naturalists, President Hitchcock attempts to name, classify, and describe the animals that made the fossil footmarks of New England, rather than to name the footmarks themselves as had previously been done. This paper contains a list of sixteen genera and thirty-five species; but apparently the limitation of space made the publication of the accompanying descriptions impossible at that time and it was not until 1848 that the detailed descriptions and illustrations appeared. In the meantime Hitchcock revised his list, abandoning among others the term *Batrachopus* (i.e., frog foot) for another descriptive name, *Anisopus* (i.e. unequal foot), this time accompanied by an adequate generic description. He never refers to *Batrachopus* again as a synonym, ignoring the name entirely.

But in the 1845 list two species are referred to *Batrachopus*: *deweyanus* which had been previously described, and *gracilis*, a new species, which was not described until 1848.

The designation of *Batrachopus deweyanus* in 1845, however, seems to give validity to the generic name even though no verbal description was given at that time, and Lull, both in 1904 and 1915, accepted it as valid on that basis.



FIGURE 104.
Batrachopus trackway,
original, one-half natural size.

Batrachopus deweyi (E. Hitchcock)

Sauroidichnites deweyi E. Hitchcock 1843, p. 261, pl. 11, fig. 9.

Batrachopus deweyanus E. Hitchcock 1845, p. 25.

Anisopus deweyanus E. Hitchcock 1848, p. 226, pl. 16, figs 5,6.; 1858, p. 60, pl. 9, fig. 3; pl. 41, fig. 2; pl. 43, figs. 1-2; pl. 53, fig. 8; pl. 58, fig. 11.

Lull, 1904A, p. 483; 1915, p. 175, fig. 32.

Holotype.—Cat. Nos. 26/s and 26/6 A. C. Hard gray shale (counterparts), with 15 tracks of both manus and pes of same individuals. Stone indurated by heat. Locality unrecorded.

Specific Characters.—Manus: Length of digit I, 7 mm.; of II, 20 mm.; of III, 25 mm.; of IV, 25 mm.; of V, 15 mm.; between lateral tips, 19 mm. Divarication of digits I and II, 53°; of II and III, 13°; of III and IV, 18°; of IV and V, 24°; of I and V, 107°.

Pes: Length of digit I, 25 mm.; of II, 38 mm.; of III, 43 mm.; of IV, 38 mm. Of foot, 43 mm.; between lateral tips, 27.5 mm. Divarication of digits I and II, 12°; of II and III, 23°; of III and IV, 6°; of I and IV, 40°. Length of the pace, 178 to 187 mm. Width of the trackway, 50 to 75 mm. Ratio of foot to pace, as 1 to 4.04. Pes angulation, 15°–40°, pace angulation, 145°. Interpes distance, 0. to 37.5 mm. to mid heel.

Localities.—North Branford, Conn. Upper (posterior) shales. Field's orchard, Turners Falls, Moody's Corner and South Hadley, Mass., Middletown, Conn. Upper (Portland) series.

Batrachopus dispar Lull (*B. deweyi* in part)

Lull 1904A, p. 483, fig. 2; 1915, p. 176, fig. 33.

Holotype, Cat. No. 21/1 A. C. On red shale from Lily Pond, Gill, Mass.

Specific Characters.—Manus: Four broad, clawless digits impressing. Divarication of digits I and II, 26°; of II and III, 68°; of III and IV, 20°; of I and IV, 122°. Length of hand, 21 mm.; its breadth, 30 mm.; between lateral tips, 28 mm.

Pes: Length of digit I from the middle point of the heel, 46 mm.; of II, 67 mm.; of III, 72 mm.; of IV, 62 mm. Length of foot, 73 mm.; between lateral tips, 53 mm. Divarication of

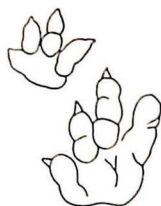


FIGURE 105.

Batrachopus deweyi
(Hitchcock), after Lull.
from Cat. No.
2041, Y. P. M.
one-half natural size.



FIGURE 106.

Batrachopus dispar
Lull, after Lull,
from the type Cat.
No. 21/1 A. C.
one-half natural size.

digits I and II, 18° ; of II and III, 20° ; of III and IV, 22° ; of I and IV, 60° .

Digits I–III bear narrow, acuminate claws, IV is clawless.

The manus is about the size of that of *B. deweyanus*; the pes nearly twice as large. The specific name implies this disparity of size between manus and pes.

Pace, 230 mm., width of trackway, 77 mm. (estimated); ratio of foot to pace, as 1 to 3.15.

Discussion.—This very rare form has only been recognized in a single slab from the Lily Pond which bears one row of ten tracks of *B. dispar*, also *B. gracilis*, *Eubrontes exsertus*, *E. tuberatus*, *E. danamus*, *Grallator cuneatus*, and others.



FIGURE 107.
Batrachopus gracilis
(Hitchcock) after Lull,
one-half natural size.

Batrachopus gracilis (E. Hitchcock)

E. Hitchcock 1845, name without description.

Anisopus gracilis E. Hitchcock 1848, p. 228, pl. 16, figs. 3, 4. (first specific description); 1858, p. 61, pl. 9, fig. 4.; pl. 35, fig. 5; pl. 36, fig. 1; pl. 43, figs. 3-5; pl. 58, fig. 9.

Anisichnus gracilis C. H. Hitchcock 1889, p. 119.

Batrachopus gracilis Lull 1904A, p. 484; 1904C, p. 381, fig. (probable footprints of *Stegomosuchus longipes*); 1915, p. 177, fig. 34.

Holotype.—Cat. No. 42/3 A. C. Slab of dark shale showing a long row of twelve impressions with four tracks of the same upon another row crossing the first. Locality unrecorded.

Specific Characters.—Manus: Length of digit I, 6 mm.; of II, 12 mm.; of III, 13 mm.; of IV, 11 mm.; of V, 4 mm. Divarication of digits I and II, 23° ; of II and III, 25° ; of III and IV, 109° ; of IV and V, 62° . Length of the hand, 13 mm.; between lateral tips, 10 mm.

Pes: Length of digit I, 11 mm.; of II, 21 mm.; of III, 25 mm.; of IV, 31 mm. Of the foot, 36 mm.; between lateral tips, 28 mm. Divarication of digits I and II, 25° ; of II and III, 20° ; of III and IV, 30° ; of I and IV, 73° .

Length of pace, 209 mm.; width of trackway, 50 mm. Ratio of foot to pace, as 1 to 5.8.

Pes angle, 20° outward, manus angle 20° .

Localities.—Horse Race, Field's Orchard, Lily Pond, Gill; below dam at Turners Falls, ferry at Turners Falls, Mass.; Portland and Middlefield, Conn. Also reported from New Jersey and Pennsylvania.

Geological Distribution.—Upper (posterior) shales and Upper (Portland) series.

Batrachopus gracilior (E. Hitchcock)

Anisopus gracilior E. Hitchcock 1863, p. 54; 1865, p. 6, pl. 1, fig. 3.

Anisichnus gracilior C. H. Hitchcock 1889, p. 119.

Lull 1904A, p. 484; 1915, p. 177, fig. 35.

Holotype, Cat. No. 46/3 A. C. On reddish shale with seventy-four tracks. Locality unrecorded.

Specific Characters.—Manus: pentadactyl track. Length of digit I, 5 mm.; of II, 8 mm.; of III, 8 mm.; of IV, 7 mm.; of V, 5 mm. Length of hand, 8 mm. Divarication of digits I and II, 35°; of II and III, 37°; of III and IV, 11°; of IV and V, 77°.

Pes: Tetradactyl, length of digit I, 9 mm.; of II, 12.5 mm.; of III, 14 mm.; of IV, 15 mm. Length of foot, 15 mm.; between lateral tips, 12 mm. Divarication of digits I and II, 14°; of II and III, 11°; of III and IV, 15.5°.

Length of pace, 46 mm.; stride, 63 mm.; width of trackway, 50 mm. Ratio of foot to pace, as 1 to 3.

Pes angle, 20°–30°.

Localities.—Horse Race, Montague, Lily Pond, Gill, and Turners Falls, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion.—*Batrachopus gracilior* differs from *B. gracilis* chiefly by its smaller size, shorter pace, and greater relative width of trackway which indicates a short-legged, wide-bodied animal and as such, not a typical *Batrachopus*.

Batrachopus bellus (E. Hitchcock)

Apatichnus bellus E. Hitchcock 1858, p. 101, pl. 17, fig. 6; pl. 35, fig. 8; pl. 45, fig. 6.

Lull 1914A, p. 485; 1915, p. 178, fig. 35 (from Cat. No. 2078 Y. P. M.).

Holotype, Cat. No. 26/21 A. C. On red shale from Field's Farm, Turners Falls, Mass.

Specific Characters.—Manus: Tridactyl, length of hand, 12.5 mm.; its width, 12.5 mm. Divarication of outer digits, 90°.

Pes: Tetradactyl, length of digit I, 7 mm.;



FIGURE 108.

Batrachopus gracilior
(Hitchcock)
after Hitchcock,
from the type.
Cat. No. 52/23 A. C.
natural size.



FIGURE 109.

Batrachopus bellus
(Hitchcock) after Lull,
from Cat. No.
2078 Y. P. M.
one-half natural size.

of II, 10 to 17 mm.; of III, 20 to 25 mm.; of IV, 15 to 20 mm.; of the foot, 26 mm. Between lateral tips, 17 mm. Projection of digit III beyond the others, 20 mm. Divarication of digits II and III, 30°; of III and IV, 30°; of the lateral digits, II and IV, 60°.

Length of pace, 75 to 100 mm.; of the stride, 175 mm. Width of trackway, 63 mm. Ratio of foot to average pace, as 1 to 3.3:1. (Measurements of type after Hitchcock.)

Localities.—Turners Falls and Lily Pond, Gill, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion.—*Batrachopus bellus* is long of limb and strictly quadrupedal, although the lightly impressed manus track is not always discernible. In size it lies between *B. gracilis* and *gracilior* but it is not always readily distinguished from the former.

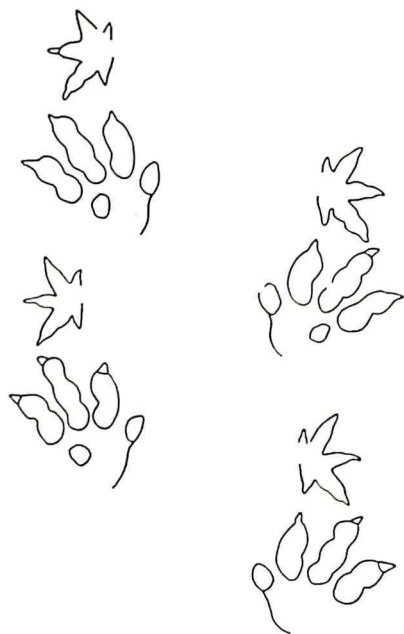


FIGURE 110.
Cheirotheroides trackway, original,
one-half natural size.

Genus *Cheirotheroides*

E. Hitchcock.

E. Hitchcock 1858, p. 130.

Lull 1904A, p. 485; 1915,
p. 179.

Generic Characters.—Quadrupedal; feet unequal in size, manus pentadactyl, pes tetradactyl. The three inner digits of each generally terminating in rounded claws, the fourth being clawless. Limbs rather short and trackway relatively wide.

Discussion.—This genus of trackways seems most closely allied to *Batrachopus*, especially to *B. gracilior* in general proportions although differing in detail.

But one species has been described: *C. pilulatus* Hitchcock, the genotype.

Cheirotheroides pilulatus E. Hitchcock

E. Hitchcock 1858, p. 130, pl. 23, fig. 4; pl. 36, fig. 6; pl. 54, fig. 3.

Lull 1904A, p. 485; 1915, p. 179, fig. 37.

Holotype, Cat. No. 34/44 A. C. (equals No. 34/31 of 1885), from Lily Pond, Gill, Mass. 19 tracks, 9 of front feet.

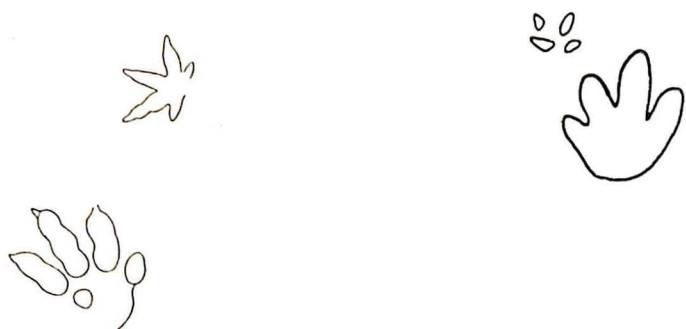


FIGURE 111.
Cheirotheroides
pilulatus Hitchcock,
after Lull,
from the type Cat.
No. 34/44 A. C.
one-half natural size.

Specific Characters.—Manus: pentadactyl, the three inner digits terminating in pellet-like claws, the outer one with none (but variable). Length of digit I, 4 mm.; of II, 8 mm.; of III, 9 mm.; of IV, 6 mm.; of V, 4 mm. Length of the hand, 11 mm.; its breadth, 11 mm. Divarication of digits I and II, 57° ; of II and III, 60° ; of III and IV, 28° ; of IV and V, 20° . Manus angle, 90° outward.

Pes: tetradactyl, plantigrade, claws on digits II to IV. Length of digit I, 10 mm.; of II, 14 mm.; of III, 18 mm.; of IV, 18 mm. Length of the foot, 22.5 mm.; between lateral tips, 14 mm. Divarication of digits I and II, 10° ; of II and III, 15° ; of III and IV, 15° ; of I-IV, 70° .

Length of the pace, 32 mm.; of the stride, 63 mm. (but variable). Width of trackway, 57 mm. Ratio of foot to pace, as 1 to 1.43. Pes angle, 20° to 30° , outward. Interpes distance, 30 mm.

Locality.—Lily Pond, Gill, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion:—*Cheirotheroides pilulatus* resembles *Batrachopus gra-*



FIGURE 112.
Comptichnus trackway, original,
natural size.

cilior most closely; differing therefrom chiefly in the rounded, pellet-like character of the claw imprints.

Genus *Comptichnus* E. Hitchcock

E. Hitchcock 1865, p. 9.

Lull 1904A, p. 538; 1915, p. 260.

Generic Characters:—Small, quadrupedal, tetradactyl, digitigrade form. Digits broad, but showing neither phalangeal pads nor distinct claws; those of the much smaller manus making peculiar ovoid marks.

But one species, *Comptichnus obesus*, has been described. It is therefore the genotype.

Discussion:—Even though the animal which made these tracks was quadrupedal, very little weight was apparently borne by the manus for only the tips of the digits seem to have touched the ground.



FIGURE 113.

Comptichnus obesus
Hitchcock, after Lull,
from the type Cat.
No. 55/5 A. C.
natural size.

Comptichnus obesus E. Hitchcock

E. Hitchcock 1865, p. 9, pl. 5, fig. 4; pl. 18, fig. 6.

Lull 1904A, p. 538; 1915, p. 260, fig. 121.

Holotype:—Cat. No. 55/5 A. C., a slab showing a row of six tracks. From the Lily Pond, Gill, Mass.

Specific Characters:—Manus: four ovoid impressions, three in front slightly radiating, and one behind. Length of manus track, 8 mm. The manus lies within and a little in advance of pes.

Pes: Compact, rounded, with four blunt digits in front and a short, broad sole (heel). Length of digit I, 6.5 mm.; of II, 9 mm.; of III, 13 mm.; of IV, 10 mm.; of the foot, 15 mm. Breadth of the foot, 16 mm. Divarication of digits I and II, 28°; of II and III, 20°; of III and IV, 14°; of the lateral digits, I and IV, 66°.

Length of pace, 65 mm. Width of trackway, 38 mm. Ratio of foot to pace, as 1 to 4.33.

Pes angle, about 10°, outward.

Pace angle, about 145°.

Interpes distance, 7 mm.

Localities:—Lily Pond and Ferry at Gill, Mass.

Geological Distribution:—Upper (Portland) series.

Genus *Shepardia* E. Hitchcock

E. Hitchcock 1858, p. 131.

Lull 1904A, p. 538; 1915, p. 259.

Generic Characters.—Quadrupedal, feet digitigrade, and nearly equal in size. Manus pentadactyl; pes tetradactyl, digits all pointing forward. Pes with clawed digits apparently connected by a web extending nearly to their extremities. Hitchcock stresses the presence of the web as the most distinctive character. It was not apparent to the writer.

But one species based upon a single specimen, *Shepardia palmipes*, the genotype.

Shepardia palmipes E. Hitchcock

E. Hitchcock 1858, p. 131, pl. 24, fig. 2.

Lull 1901A, p. 538; 1915, p. 260, fig. 120.

Holotype.—Cat. No. 33/47 A. C. Amherst College. From below the cataract at Turners Falls, Mass.

Specific Characters.—Manus: Length of digit I, 10 mm.; of II, 18 mm.; of III, 23 mm.; of IV, 26 mm.; of V, 10 mm. Length of hand, 23 mm.; between lateral tips, 18 mm. Divarication of digits I and II, 30°; of II and III, 25°; of III and IV, 20°; of IV and V, 30°.

Pes: Length of digit I, 13 mm.; of II, 25 mm.; of III, 30 mm.; of IV, 23 mm. Length of the foot, 30 mm.; between lateral tips, 18 mm. Divarication of digits I and II, 10°; of II and III, 13°; of III and IV, 14°.

Pes angle somewhat outward from the median line. Manus position a little in advance of that of the pes.

Other details unrecorded. Hence no track pattern is possible.

Localities.—Lily Pond, Gill, Turners Falls, Mass.

Geological Distribution.—Upper (Portland) series.

Group IX. Habitually quadrupedal.

Pes: tridactyl or tetradactyl. Plantigrade.

Manus: much smaller than pes and pentadactyl.

Pace short. Trackway wide.

Genera: *Ammopus*, *Corvipes*, *Palamopus*.



FIGURE 114.

Shepardia palmipes
Hitchcock, after Lull.
from the type Cat. No.
33/47 A. C. Amherst.
Natural size.

Genus *Ammopus* Marsh

O. C. Marsh 1896 B. pl. 5, fig. 1 (figure but no description).

Lull 1915, p. 263.

Generic Characters.—Small, quadrupedal, plantigrade, feet unequal in size. Manus pentadactyl; pes tetradactyl, with broad rounded heel. Digits all curved, but without separate claw or phalangeal pad impressions.

Pace short and trackway rather broad.

But one species described: *A. marshi* Lull, the genotype.

Discussion.—The pes of *Ammopus* resembles that of *Platypterna deanii*, while the manus is like that of *Corvipes*, the pes less so.

Ammopus marshi Lull

Lull 1915, p. 264, figs. 125, 126.

Holotype.—Cat. No. 2040 Y. P. M. counterparts; from the Ferry at Gill above Turners Falls, Mass.

Specific Characters.—Manus: elongate with three anterior digits curving outwardly, and one spur-like digit (I) arising from the inner side of the elongated palm. Digit V at right angles to the axis of the hand. Palm terminating in an outwardly curving point. Length of manus, 20 to 21 mm.; its breadth across anterior digits, 18 mm.

Pes: Broad, with a rounded heel and three anterior digits and the terminal imprint of another, the first, about 8 mm. behind the heel. Length of digit II, 12 mm.; of III, 27 mm.; of IV, 17 mm. Length of the foot, 35 mm.; between lateral tips, 22.5 mm. Hallux claw imprint to rear of broad heel. Digit II curved axially; III with a sigmoid curve, terminating outwardly; IV, also sigmoid, terminating inwardly. Divarication of digits II and III, 27°; of III and IV, 47°; of the lateral digits, II and IV, 60°. (Because of the marked curvature of digit II the degrees of divarication are not reliable.)

Length of pace, 96 mm.; of the stride, 158 mm.; width of trackway, 84 mm. Ratio of foot to pace, as 1 to 2.743.

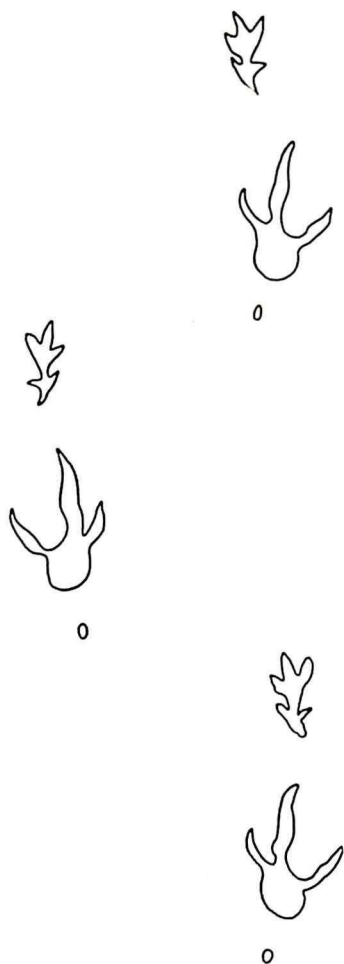


FIGURE 115.
Ammopus trackway, original,
one-half natural size.

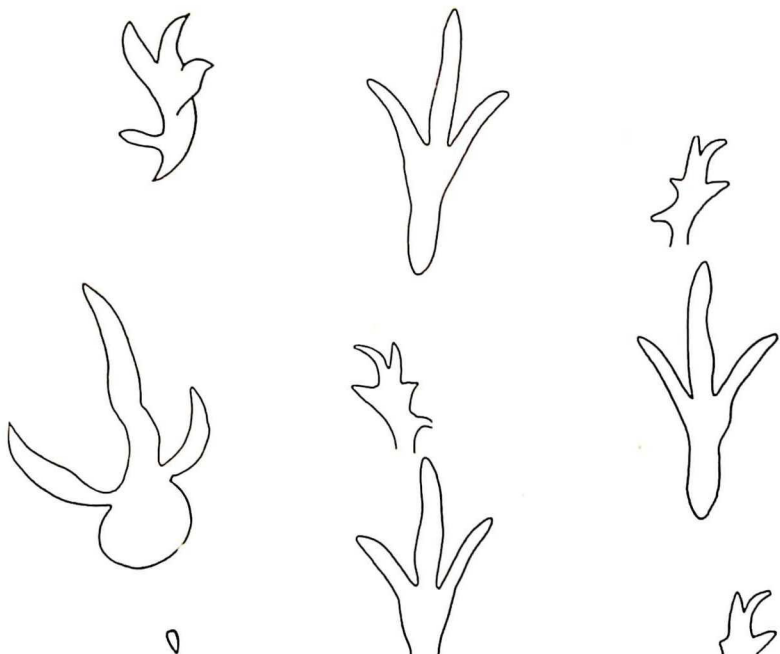


FIGURE 116.

Ammopus marshi
Lull, after Lull,
from the type Cat.
No. 2040 Y. P. M.
natural size.

Pes angulation, 0° ;
pace angulation, 114° .

Interpes distance, 35
mm.; axis, 54 mm.

Position of manus in
front of, or within, or with-
out that of the pes. These
dimensions are variable in
the successive steps of the
same animal.

This species is dedica-
ted to Professor O. C.
Marsh, who named the ge-
nus, and figured the type,
but without specific name
or description.

Localities:—Turners Falls Ferry, Gill; Lily Pond, Gill, Mass.

Geological Distribution:—Upper (Portland) series.

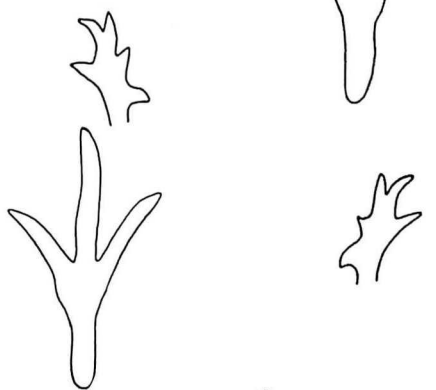


FIGURE 117.

Corvipes trackway, original, one-half natural size.

Genus *Corvipes* E. Hitchcock

E. Hitchcock 1858, p. 98.

Lull 1904A, p. 509; 1915, p. 246.

Generic Characters:—Quadrupedal, semi-plantigrade. Pes tridactyl with a long, narrow heel. Manus pentadactyl, digits curved. Position of the manus print a little in advance of, sometimes without, again covered in part by that of the pes.

Tips of digits more or less acuminate.

No distinct claws or phalangeal pad impressions.

But one species, *C. lacertoideus*, has been described. It is therefore the genotype.

Discussion:—The manus imprint of *Corvipes* resembles that of *Amomopus* in general shape. The pes, on the other hand, differs especially in the shape of the long, narrow heel.

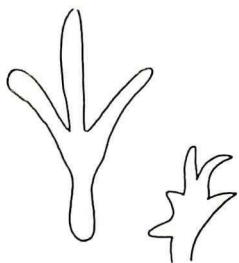


FIGURE 118.

Corvipes lacertoideus
Hitchcock, after Hitchcock,
from the type Cat.
No. 32/1 A. C.
one-half natural size.

Corvipes lacertoideus E. Hitchcock

E. Hitchcock 1858, p. 98, pl. 17, fig. 3;
pl. 35, fig. 7; pl. 47, fig. 1.

Lull 1904A, p. 510; 1915, p. 246, fig. 104.

Holotype:—Cat. No. 32/1 A. C., on sandstone from Turners Falls, Mass.

Specific Characters:—Manus: pentadactyl. Length of digit I, 10 mm.; of II, 10 mm.; of III, 19 mm.; of IV, 20 mm.; of V, 15 mm.; of the hand, 30 mm. Divarication of digits I and V, 160°.

Pes: Tridactyl. Length of digit II, 33 mm.; of III, 43 mm.; of IV, 33; length of heel, 22 mm.; of the foot, 66 mm.; between lateral tips, 35 mm. Divarication of digits II and III, 40°; of III and IV, 35°; of the lateral digits, II and IV, 75°.

Length of pace, 43 to 68 mm.; width of trackway, 116 mm.

Ratio of foot to average pace, as 1 to 0.83.

Pes angulation, 0° to 10°, inward.

Interpes distance (heels), 0–76 mm.

Localities:—Horse Race, Lily Pond, and Field's orchard in Gill; Turners Falls, Mass., Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion.—The resemblance of the hand of *Corvipes* to that of *Ammopus* has already been mentioned. There is also a similarity between it and that of *Plectropterna gracilis*, and the pes tracks are also similar, except that in the latter the heel is relatively longer and bears a hallux impression which is not, with one possible exception, present in *Corvipes*. This difference may be due, however, to posture, for even when a hallux is known to be present in a species it is not always in evidence in a given track.

Genus **Palamopus** E. Hitchcock

E. Hitchcock 1845, p. 24.

Sillimanius E. Hitchcock 1845, p. 24 (in part).

Macropterna E. Hitchcock 1858, p. 128.

¹E. Hitchcock 1858, p. 127 = *Eupalamopus* Hay.

Lull 1904A, p. 532; 1915, p. 252.

Generic Characters.—Quadrupedal; manus and pes of unequal size, the latter being from two to three times the length of the former. Feet plantigrade. Pes tetradactyl. Manus pentadactyl, no claw or phalangeal pad impressions; caudal trace sometimes present.

Three species have been described, eliminating the form now referred to *Eupalamopus*. They are: *Palamopus palmatus*, the genotype, together with *P. rogersi* and *P. gracilipes*.

Palamopus palmatus (E. Hitchcock)

Sauroidichnites palmatus E. Hitchcock 1841, p. 483, pl. 34, figs. 15, 16.

Palamopus anomalus E. Hitchcock 1845, p. 24.

Macropterna recta E. Hitchcock 1848, p. 235, pl. 15, fig. 6.

¹O. P. Hay (1902, p. 548) writes: "This is not the *Palamopus* of 1848 and subsequently The latter is here replaced by *Eupalamopus*."

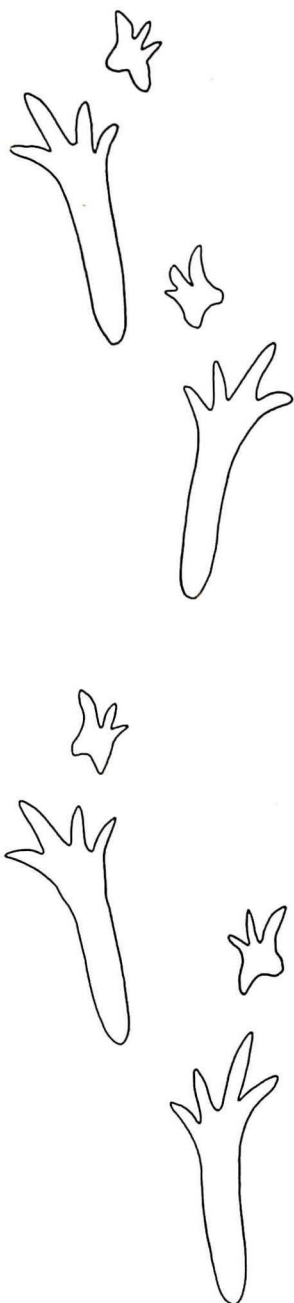


FIGURE 119.

Palamopus trackway, original, one-half natural size.

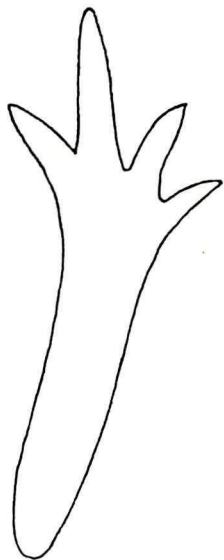


FIGURE 120.
Palamopus palmatus
(Hitchcock) after Hitchcock,
from the type Cat.
No. 27/3 A.C.
natural size.

Macropterna divaricans E. Hitchcock
1848, p. 237, pl. 15, fig. 7; 1858, p. 129, pl.
23, fig. 7.

Palamopus divaricans Lull 1904A, p. 532.

Palamopus palmatus, Lull 1915, p. 252,
fig. 109.

Holotype:—Cat. No. 27/3 A.C., on red
shale from Turners Falls, Mass.

Specific Characters:—Manus: with five
digits radiating through about 180° . Length
of hand, 23 mm.; its breadth, 18 mm.

Pes: Length of digit I, 13 mm.; of II,
15 mm.; of III, 17 mm.; of IV, 15 mm.; be-
tween lateral tips, I and IV, 30 mm.; length
of heel, 43 mm.; its breadth, 12 mm. Length
of foot, 69 mm. Divarication of digits I and
II, 20° ; of II and III, 30° ; of III and IV,
 40° ; of I and IV, 90° .

Length of pace, 84 to 178 mm.; width
of trackway, 76 mm. Ratio of foot to average
pace, as 1 to 1.9.

Pes angle, 0° to 90° . Interpes distance
from mid-heel, 0 to 50 mm.

Localities:—Horse Race in Gill, Turners
Falls, Mass.

Geological Distribution:—Upper (Port-
land) series.

Palamopus gracilipes (E. Hitchcock)

Macropterna gracilipes, E. Hitchcock,
1858, p. 129, pl. 23, fig. 6; pl. 34, fig. 1 (from
No. 39/66 A.C.).

Lull 1904A, p. 533; 1915, p. 253, fig. 110.

Type:—Cat. No. 35/23 A.C., on shale from Turners Falls, Mass.
Also Cat. No. 39/77 A.C. from Turners Falls and No. 55/38 A.C. from
the Lily Pond, Gill, Mass.

Specific Characters:—Minute form. Manus:
but four digits impressing; form and divarica-
tion about those of the pes. Length, 9 mm.;
breadth, 5 mm.

Pes: digitigrade; length of digit I, 4 mm.;
of II, 7 mm.; of III, 8 mm.; of IV, 7 mm.; of
the heel, 7 mm.; of the foot, 15 mm. Divarica-
tion of digits I and II, 40° ; of II and III, 25° ;



FIGURE 121.
Palamopus gracilipes
(Hitchcock)
after Hitchcock,
from Cat. No. 35/23
A.C. natural size.

of III and IV, 25° ; of the lateral digits, I and IV, 90° .

Length of stride, 38 to 48 mm.; average pace, 21 mm. Width of trackway, 30 mm. Ratio of foot to pace, as 1 to 1.4.

Pes angulation, slightly outward. Distance between heels, 14 mm.

Localities:—Turners Falls and Lily Pond, Gill, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—Aside from its minute size *Plectropterna gracilipes* differs markedly from the two other species, for the foot apparently lacks the long heel and plantigrade pose of the others, and the manus also differs.

***Palamopus rogersi* (E. Hitchcock)**

Ornithoidichnites minimus E. Hitchcock
1841, p. 496, pl. 45, fig. 41 (in part).

Ornithoidichnites rogersi E. Hitchcock
1843, p. 256, pl. 11, fig. 7.

Argoides minimus E. Hitchcock 1845, p.
24 (in part).

Sillimanianus rogersianus E. Hitchcock
1845, p. 24 (in part).

Macropterna rhynchosauroides E. Hitch-
cock 1848, p. 233, pl. 15, fig. 9.

Macropterna vulgaris E. Hitchcock 1858,
p. 128, pl. 23, fig. 5; pl. 35, fig. 9; pl. 37,
fig. 4; pl. 48, fig. 7; pl. 49, fig. 3; pl. 58, fig. 14.

Palamopus rogersi Lull 1915; p. 253,
fig. 111.

Cotypes:—Cat. Nos. 36/52, and 39/79,
A. C., from Turners Falls, Mass.

Specific Characters:—Manus: Five digits impressing, ranging through
 180° ; length of hand, 15 mm.; its breadth, 11 mm.

Pes: Length of digit I, 5 mm.; II, 9 mm.; III, 12 mm.; IV, 12 mm.;
of heel, 15 mm.; of foot, 28 mm.; between lateral tips, 15 mm. Divarica-
tion of digits I and II, 30° ; of II and III, 20° ; of III and IV, 30° ; of
the lateral digits, I and IV, 80° .

Length of pace, 46 mm. Width of trackway, 50 mm. Ratio of foot
to pace, as 1 to 1.64. Caudal trace sinuous but not always present.

Pes angle, 10° to 20° outward. Distance between heels, 20 mm.

Localities:—Horse Race, Lily Pond, north bank below Turners
Falls, Turners Falls, Field's orchard in Gill, Mass. Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.



FIGURE 122.

Palamopus rogersi
(Hitchcock) after Hitchcock,
from the type Cat. No.
36/52 A.C. natural size.

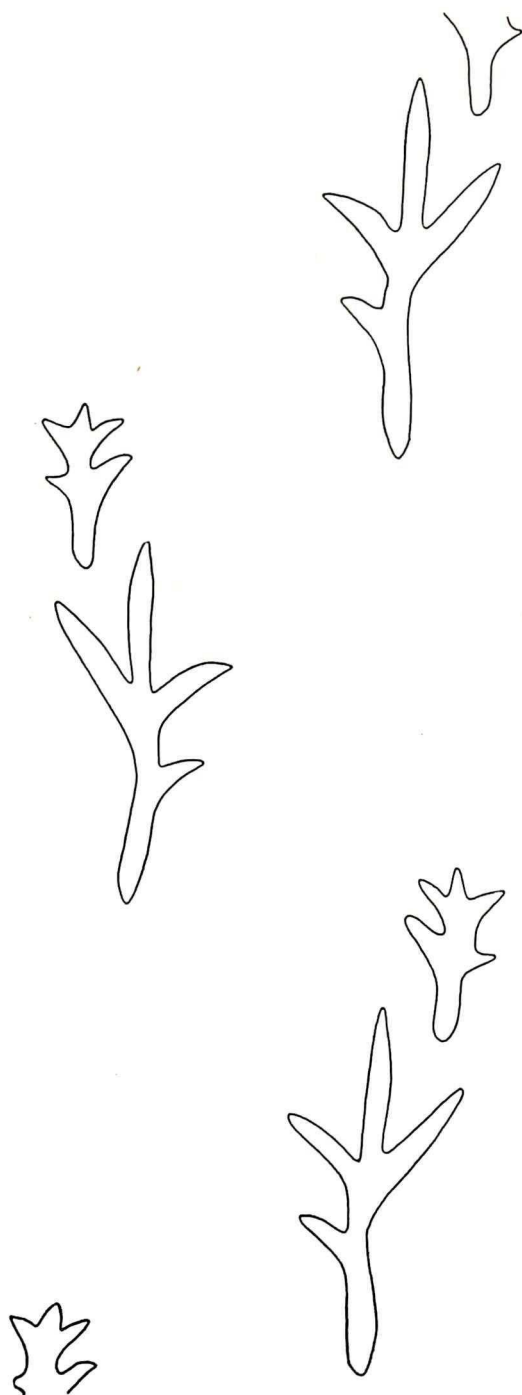


FIGURE 123.
Plectropterna trackway, original, one-half natural size.

Discussion:—*Palamopus rogersi* resembles *P. palmatus* very closely except for its much smaller size and the shape and orientation of the manus.

Group X. Habitually quadrupedal. Pes tetradactyl with well developed hallux. Manus, tridactyl to pentadactyl. Manus imprint varies from very light with only the tips of the digits showing to a full impression with an elongated carpus.

Pace short.

Trackway medium to wide.

Genera: *Plectropterna*, *Harpedactylus*, *Exocampe*, *Xiphopeza*, *Tarsodactylus*.

Genus *Plectropterna* E. Hitchcock

Plectropus E. Hitchcock 1845, p. 24 (in part); 1848, p. 198 (in part).

E. Hitchcock 1858, p. 108 (in part) for *Plectropus* preoccupied.

Tarsoplectrus Lull 1904A, p. 519.

Lull 1915, p. 232.

Generic Characters:
 —Bipedal in gait, occasionally quadrupedal. Pes tetradactyl, plantigrade, heel narrow, generally tapering backward, not always wholly

impressing. Hallux spur-like, usually recurved backward and acuminate. Three anterior digits slender, fairly straight, rarely showing phalangeal pads or distinct claws.

Genotype:—*Plectropterna minitans* (E. Hitchcock). Four additional species: *P. angusta*, *lineans*, *elegans*, and *gracilis*.

Discussion:—In 1904 Lull considered the type species *P. minitans* synonymous with *Anomarpus intermedius* and as a consequence gave the genus a new name, *Tarsoplectrus*, with *T. angustus* as the genotype. In 1915, however, Lull said "I am not now fully convinced of this synonymy and prefer to let the old name, *Plectropterna*, stand."

Plectropterna minitans
(E. Hitchcock)

Sauroidichnites minitans
E. Hitchcock 1841, p. 481, pl. 33, fig. 11.

Plectropus minitans and
longipes E. Hitchcock 1845,
p. 24; 1848, p. 198, pl. 9,
figs. 2,3; pl. 10, figs. 1-3.

E. Hitchcock 1858, p. 108,
pl. 18, fig. 2; pl. 19, figs. 10-12.

Anomarpus intermedius
Lull 1904A, pp. 510, 520.

Lull 1915, p. 232, fig. 86.

Holotype:—Cat. No. 34/35 A. C. A single track of great size, from the north bank [Gill] below Turners Falls, Mass.

Specific Characters:—Manus: unknown. Pes: Length of digit I, 37 mm.; of II, 76 mm.; of III, 120 mm.; of IV, 86 mm.; of the heel, 109 mm.; of the foot, 230 mm. Distance between lateral tips, 100 mm. Divarication of digits II and III, 38°; of III and IV, 37°; of the lateral digits, II and IV, 75°.

Length of the pace, 405 mm.; width of the trackway, 228 mm. Ratio of foot to pace, as 1 to 1.76.

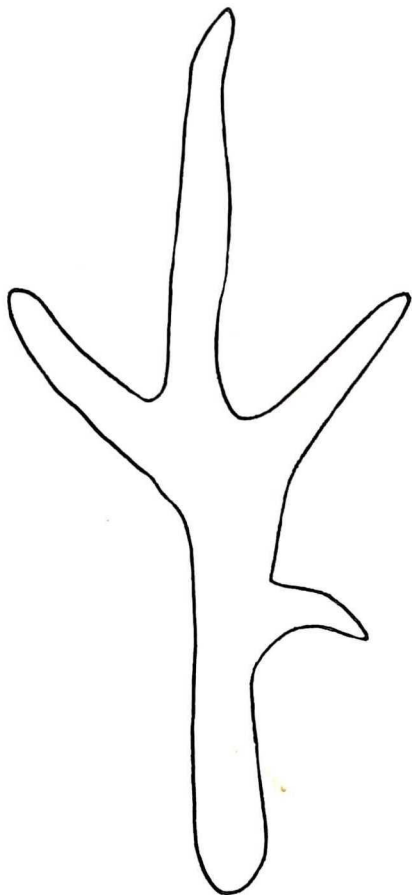


FIGURE 124.
Plectropterna minitans (Hitchcock),
after Lull, from the type Cat. No.
34/35 A. C. one-half natural size.

Pes angle unrecorded.

Digit I a sharply curved spur, arising about 35 mm, back of the roots of the forward toes.

Localities:—North bank below Turners Falls, Turners Falls, Field's orchard in Gill, Chicopee Falls, and near Cabotville, Mass.; Wethersfield Cove and Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

***Plectropterna gracilis* E. Hitchcock**

E. Hitchcock 1858, p. 109, pl. 18, fig. 3; pl. 48, fig. 2; 1865, p. 24, pl. 17, fig. 1 (photograph of No. 51/19 A. C.).

Lull 1904A, p. 528 (a possible synonym for *Harpedactylus tenuissimus*, omitted in 1915).

Cotypes:—Cat. Nos. 34/9, 51/19 A. C., from Turners Falls and from Field's Farm, Gill, Mass. On red sandstone.

Specific Characters:—Quadrupedal; Manus: pentadactyl, four toes pointing forward, one at right angles to the axis, palm (heel) prolonged backward. Length of hand, 45 mm. of which about half is the heel. Position a little outside and in front of the pes.

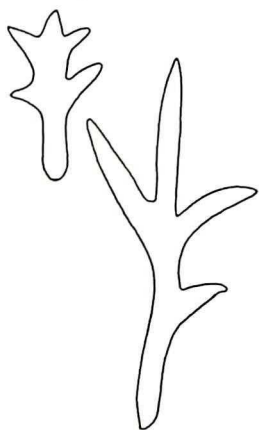


FIGURE 125.
Plectropterna gracilis
(Hitchcock), after Hitchcock,
one-half natural size.

Pes:—Tetradactyl, plantigrade. Digits slender and acuminate. Length of digit I, 15 mm.; of II, 27.5 mm.; of III, 45 mm.; of IV, 37 mm. Length of the foot, 96 mm.; of the heel, 50 mm.; between lateral tips, 50 mm. Divarication of digits II and III, 57°; of III and IV, 37°; of the lateral digits, II and IV, 94°. Length of the pace, 100 to 126 mm.; of the stride, 178 mm. Width of the trackway, 70 to 123 mm.

Ratio of foot to average pace, as 1 to 1.18.

Pes angle, about 0°. Pace angle, 160°.

Interpes distance (to mid-heels), about 70 mm.

Locality:—Field's Farm, Gill, and Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—This form resembles *Plectropterna minitans* except that it is about half the size of the latter and the hallux is not recurved.

***Plectropterna angusta* E. Hitchcock**

E. Hitchcock, 1858, p. 110, pl. 18, fig. 4; pl. 36, fig. 3.

Tarsoplectrus angustus Lull 1904A, p. 520.

Plectropterna angusta Lull 1915, p. 233, fig. 87.

Holotype.—Cat. No. 33/39 A. C., from Turners Falls, Mass.

Specific Characters.—Manus unknown. Pes: Length of digit I, 18 mm.; of II, 50 mm.; of III, 70 mm.; of IV, 46 mm.; projection of digit III beyond the others, 31 mm. Length of the foot, 105 mm.; between lateral tips, 40 mm.; of the heel, 35 mm. Divarication of digits I and II, 95°; of II and III, 22°; of III and IV, 25°; of the lateral digits, II and IV, 47°.

Length of the pace, 305 mm.; width of the trackway, 68 mm. Ratio of foot to pace, as I to 2.9.

Toes slender, lateral ones slightly curved outward. Hallux strongly recurved, arising about the mid length of the heel.

Pes angle 0°; pace angle, nearly 180°.

Localities.—Field's Farm, Lily Pond, Gill, Turners Falls, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion.—*Plectropterna angusta* resembles *P. minitans* except that it is about half the size of the former but has a relatively wider heel, as the figures will show.

Plectropterna elegans C. H. Hitchcock

C. H. Hitchcock 1889, pp. 122, 125 (no figures).

Tarsoplectrus elegans Lull 1904A, p. 521.

Lull 1915, p. 234, fig. 88.

Cotypes.—Cat. Nos. 53, 91, 242, Mt. Holyoke collection, from Wethersfield, Conn. (destroyed by fire).

Specific Characters.—Pes: Length of digit I, 22 mm.; of II, 26 to 45 mm.; of III, 51 to 76 mm.; of IV, 37 to 44 mm.; of the foot, 126 to 131 mm.; between lateral tips, 50 to 60 mm.; of the heel, 44 to 50 mm.



FIGURE 126.
Plectropterna angusta
Hitchcock,
after Hitchcock,
one-half natural size.

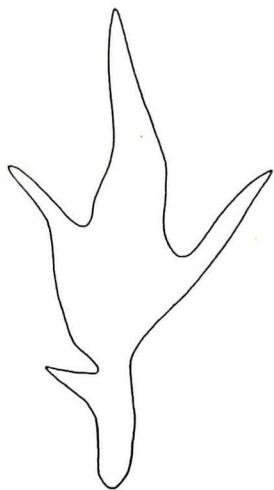


FIGURE 127.
Plectropterna elegans
C. H. Hitchcock, after Lull,
from the type specimens,
Cat. Nos. 53, 91, and 242,
Mt. Holyoke Collection,
one-half natural size.

Projection of digit III beyond the others, 44 to 48 mm. Divarication of digits II and III, 30° ; of III and IV, 40° ; of the lateral digits, II and IV, 70° .

Length of pace, 457 to 533 mm.; width of the trackway, 77 mm. Ratio of average foot to average pace, as 1 to 3.87.

Locality:—Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion:—Animal walks nearly in a right line, heel of *elegans* very narrow; hallux straight, pointing slightly forward from beginning of the heel.



FIGURE 128.
Plectropterna lineans
Hitchcock,
after Hitchcock,
from the type Cat.
No. 36/42 A. C.
one-half natural size.

***Plectropterna lineans* E. Hitchcock**

E. Hitchcock 1858, p. 110, pl. 18, fig. 5.

?*Harpedactylus tenuissimus* Lull 1904A,
p. 527.

Lull 1915, p. 234, fig. 89.

Holotype:—Cat. No. 36/42 A. C., on red shale, Wethersfield, Conn.

Specific Characters:—Quadrupedal. Manus: tetradactyl; toes all curve inward. Length of hand, 25 mm.; its breadth, 20 mm.

Pes: Length of digit I, 12 mm.; of II, 30 mm.; of III, 48 mm.; of IV, 28 mm.; of heel, 18 mm. Length of foot, 66 mm.; Projection of digit III beyond the others, 22 mm. Between lateral tips, 28 mm. Divarication of digits II and III, 25° ; of III and IV, 42° ; of the lateral digits, II and IV, 67° .

Length of step, 254 mm.; width of trackway, 35 mm. Ratio of foot to step, as 1 to 3.85.

Pes angle, several degrees outward.

Localities:—Lily Pond, Gill; Turners Falls, Mass., and Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Plectropterna lineans* is the smallest of the genus, but resembles the other species except that the hallux impression while inclined slightly forward is separated from the heel mark at its base.

Genus *Harpedactylus* E. Hitchcock

Sauroïdichmites (in part) E. Hitchcock 1841, p. 482.
E. Hitchcock 1848, p. 24.

Lull 1904A, p. 527; 1915, p. 245.

Generic Characters.—Quadrupedal, tetradactyl, plantigrade, heel long, digits sometimes curved, sickle-like (hence the name); generally the inner two inward, the fourth outward, sometimes inward. No phalangeal pads or claws visible in the track. Manus variable, not always impressing.

Four species of *Harpedactylus* have been described: *H. tenuissimus* (the genotype), *H. gracilior*, *H. crassus*, and *H. concamerata*. Of these, *tenuissimus* and *gracilior* are quite similar except for size, while *H. crassus* is very unlike either of them.

H. concamerata is more closely affiliated with the genus *Platypterna* and is described as of that genus. (See p. 223; fig. 90).

***Harpedactylus tenuissimus* (E. Hitchcock)**

Sauroidichnites tenuissimus E. Hitchcock
1841, p. 482, pl. 34, fig. 13.

E. Hitchcock 1845, p. 24.

Harpedactylus gracilis E. Hitchcock 1848,
p. 206, pl. 14, fig. 2; 1858, p. 112, pl. 20, fig. 4;
pl. 52, fig. 5.

Lull 1904A, p. 527; 1915, p. 245, fig. 102.

Holotype.—Cat. No. 27/18 A. C., from below Turners Falls, Mass.

Specific Characters.—Manus: tetradactyl with four small ovoid impressions ranging through about 80 degrees. Length of hand, 27 mm.

Pes: tetradactyl, plantigrade, with a long, narrow heel. Hallux arising near beginning of heel and pointing obliquely forward. Digits slender, sometimes slightly curved inward. Length of digit I, 22 mm.; of II, 33 mm.; of III, 53 mm.; of IV, 40 mm. Projection of III beyond the lateral toes, 22 mm. Length of the heel, 55 mm.; its breadth, 5 mm.; of the foot, 90 mm. Distance between lateral tips, 51 mm. Divarication of digits I and II, 19°; of II and III, 30°–50°; of III and IV, 50°–58°; of the lateral digits, II and IV, 84°–100°.

Length of pace, 76 to 87 mm.; width of trackway, 126 mm. Ratio of foot to average pace, as 1 to 0.9.

Pes angulation, nearly 0°. Interpes distance (between heels), 44 mm.

Localities.—North bank below Turners Falls, Turners Falls, Mass., and Wethersfield, Conn.

Geological Distribution.—Upper (Portland) series.



FIGURE 129.
Harpedactylus
tenuissimus
(Hitchcock.)
after Hitchcock,
one-half natural size.



FIGURE 130.
Harpedactylus
gracilior Hitchcock,
after Hitchcock,
one-half natural size.

***Harpedactylus gracilior* E. Hitchcock**

E. Hitchcock 1865, p. 12, pl. 3, fig. 2.

Lull 1904A, p. 528; 1915, p. 246, fig. 103.

Cotypes:—Cat Nos. 47/52 and 55/1 A. C., from the north bank below Turners Falls, Mass.

Specific Characters:—Manus: unknown. Pes: Length of digit I, 7 mm.; of II, 17 mm.; of III, 22 mm.; of IV, 17 mm.; of the heel, 19 mm. Length of the foot, 40 mm.; between lateral tips, 25 mm. Divarication of digits I and II, 52°; of II and III, 31°; of III and IV, 78°; of I and IV, 90° to 158°.

Length of pace, 90 mm.; width of trackway, ? 34 mm. Ratio of foot to pace, as 1 to 2.25.

Localities:—Lily Pond, Gill, and the north bank (Gill) below Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Harpedactylus gracilior* is similar to *H. tenuissimus* except for size, being about one-half the dimensions of the latter. The ratio of foot to pace, however, always a variable factor, is at least twice as great.

***Harpedactylus crassus* E. Hitchcock**

E. Hitchcock 1865, p. 12, pl. 3, fig. 1.

Lull 1904A, p. 528; 1915, p. 246.

Holotype:—Cat. No. 47/53 A. C. A smoothed specimen of gray shale. Locality unrecorded.

Specific Characters:—Manus: pentadactyl, plantigrade, heel stout,



FIGURE 131.

Harpedactylus crassus Hitchcock, after Hitchcock, from the type, Cat. No. 47/53 A. C. one-half natural size.

not fully impressed. Digits stout and little curved; pollex almost at right angles with the axis of the hand. Heel about 15 mm. in the track. Length of the hand as impressed, 49 mm.; between lateral tips, II and V, 45 mm. (from Hitchcock's figure).

Pes: Tetradactyl, digits rather slender with rounded tips. Digits I to III curved strongly inward; digit IV, outward. Length of digit I, measured on the chord, 20 mm.; of II, 53 mm.; of III, 53 mm.; of IV, 40 mm. Thickness of heel, 13 mm. Length of the foot, about 90 mm.; between lateral tips, 92 mm. Divarication (taken from Hitchcock's figure) of digits II and III, 35°; of III and IV, 81°; of the lateral digits, II and IV, 120°. As there are only isolated tracks preserved the pace and trackway are unknown.

Localities:—Unrecorded, probably from the Turners Falls region.

Discussion:—Hitchcock's figure of the pes drawn from the ground-down slab when wetted, resembles that of *Steropoides divaricatus* very closely except for the size. The manus of the latter is unknown (see Lull 1915, p. 241, fig. 97). If these species prove to be synonymous, *Steropoides divaricatus* has priority.

Genus *Exocampe* E. Hitchcock

E. Hitchcock 1858, p. 142.

Lull 1904A, p. 534; 1915, p. 254.

Generic Characters:—Quadrupedal. Pes: tetradactyl, digitigrade or plantigrade; heel not always impressing in the track. The three outer digits turned outward, inner digit more nearly straight.

Manus: pentadactyl, about one-half the length of the pes track; but not always present.

Legs of moderate length, body narrow.

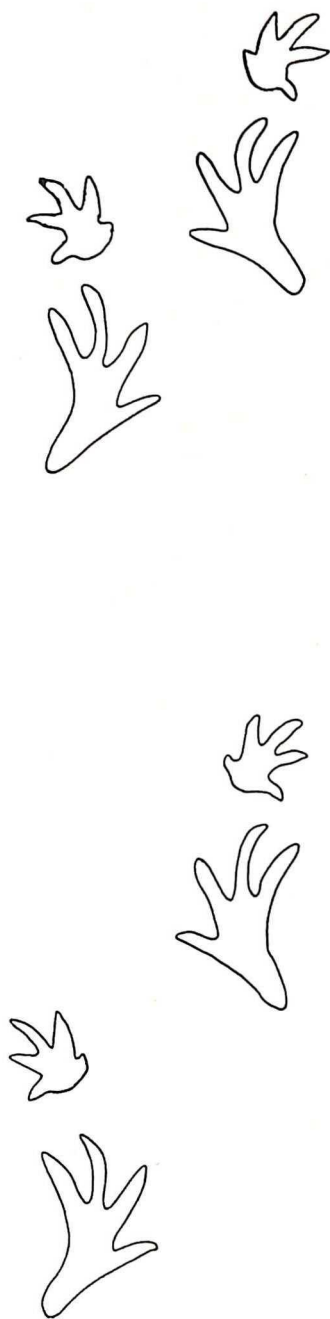


FIGURE 132.

Exocampe trackway, original, one-half natural size.

Three species of *Exocampe* have been described: *E. arcta*, the genotype, and *E. ornata* and *minima* all from the Upper (Portland) series.

They differ largely in size and limb proportions.



FIGURE 133.
Exocampe arcta Hitchcock,
after Lull from the type
Cat. No. 35/24 A.C.
natural size.

Exocampe arcta E. Hitchcock

E. Hitchcock 1858, p. 142, pl. 25, figs. 5,6,10; pl. 49, fig. 5.

Lull 1904A, p. 534; 1915, p. 254, fig. 112.

Holotype:—Cat. No. 35/24, A.C., from north bank (Gill) below Turners Falls, Mass.

Specific Characters:—Manus: Length of digit I, 9 mm.; of II, 22 mm.; of III, 25 mm.; of IV, 25 mm.; of V, 12 mm.; of the hand 27 mm. Divarication of lateral digits, 110° .

Pes: Length of digit I, 20 mm.; of II, 27 mm.; of III, 32.5 mm.; of IV, 32.5 mm.; of the foot, 48 mm.; of the heel, 20 mm.; between lateral tips, 28 mm. Divarication of outer digits, 110° .

Length of stride, 63 to 215 mm. Width of trackway, 75 mm.

Pes angle, about 30° inward. Interpes distance, 50 mm. from mid-heel.

Locality:—Turners Falls and north bank (Gill), below Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—Three outer toes of pes curved sharply outward, those of manus more nearly straight. No phalangeal pads or distinct claws.

Exocampe ornata E. Hitchcock

E. Hitchcock 1858, p. 143, pl. 25, fig. 11; pl. 48, figs. 1,6.

Lull 1904A, p. 534; 1915, p. 255, fig. 113.

Cotypes:—Cat. Nos. 39/69 and 41/39 A.C. First from Turners Falls, the other bears ten tracks and is from below the dam, Turners Falls, Mass.



FIGURE 134.
Exocampe ornata
Hitchcock,
after Hitchcock,
natural size.

Specific Characters.—Manus: four digits directed forward and one to the rear. Length of each of the digits, about 7 mm. Divarication of anterior digits, 130° . Length of the hand, 13 mm.

Pes: Length of digit I, 6 mm.; of II, 7 mm.; of III, 10 mm.; of IV, 7 mm.; of the foot, about 12 mm. Between lateral tips, 13 mm. Divarication of the lateral digits, 100° to 160° .

Length of the stride, 100 mm. Width of trackway, 25 mm. Ratio of foot to stride, as 1 to 8.3.

Pes angulation, 15° to 25° , outward. Manus angulation, 40° to 70° outward.

Interpes distance, 14 to 3.6 mm. (mid-heels).

Localities.—Lily Pond, Gill, Turners Falls and below dam at Turners Falls, Mass., and Wethersfield, Conn.

Geological Distribution.—Upper (Portland) series.

Remarks.—*E. ornata* differs from *E. arcta* by its smaller size, relatively much greater stride and absence of heel in the tracks.

Exocampe minima E. Hitchcock

E. Hitchcock 1865, p. 11, pl. 18, fig. 3.

C. H. Hitchcock in E. Hitchcock 1865, Appendix C, p. 89.

Lull 1904A, p. 534; 1915, p. 255.

Holotype.—Cat. No. 55/4 A. C., Field's orchard, Gill, Mass.

Specific Characters.—Manus: Four digits in front with a divarication of 138° . Rear toe short. Digits straight and varying in length from 4 to 5 mm.

Pes: Tetradactyl. Length of digit I, 3 mm.; of II, 6 mm.; of III, 7.5 mm.; of IV, 4 mm.; of the foot with heel, about 11 mm. Divarication of lateral digits, 100° to 130° .

Delicate claws and heel sometimes impressing.

Length of stride, 27 to 50 mm. Width of trackway, 38 mm. Ratio of foot to average stride, as 1 to 3.5.

Pes angulation, 15° to 50° , outward.

Interpes distance, from 10 to 22 mm.

Locality.—Field's orchard, Gill, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion.—*E. minima* differs from *E. ornata* in its smaller size, wider trackway, and irregularity of progression, as though it were a clumsier animal in spite of its small size.



FIGURE 135.
Xiphopeza trackway, original,
one-half natural size.

Genus *Xiphopeza* E. Hitchcock

E. Hitchcock 1848, p. 239;
1858, p. 113.

Lull 1904A, p. 526; 1915,
p. 243.

Generic Characters:—Quadrupedal, possibly not habitually so; feet unequal in size, Pes tetradactyl, plantigrade, three toes directed forward; the hallux nearly in line with the fourth toe. Heel elongated. Manus rarely impressed and showing but three digits in the track.

But one species has been described: the genotype *Xiphopeza triplex* E. Hitchcock.

Xiphopeza triplex

E. Hitchcock

E. Hitchcock 1848, p. 239,
pl. 15, fig. 8; 1858, p. 113, pl.
20, fig. 6; pl. 52, figs. 2,4,6.

Lull 1904A, p. 526; 1915,
p. 243, fig. 100.

Holotype:—Cat. No. 41/26
A. C., on gray shale from Turners Falls, Mass.

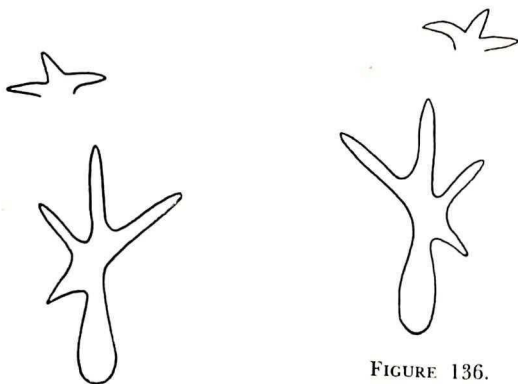


FIGURE 136.
Xiphopeza triplex
Hitchcock,
after Hitchcock,
one-half natural size.

Plesiotype:—Cat. No. 27/13 A. C. Figured by Lull.

Specific Characters:—Quadrupedal. Manus: but three digits in the one known track; averaging about 10 mm. in length. Probably five digits in the complete hand.

Pes: tetradactyl, plantigrade in walking, digits slender, without phalangeal pads or distinct claw imprints. Length of digit I, 13 mm.; of II, 20 mm.; of III, 38 mm.; of IV, 28 mm.; of the heel, 30 mm.; its breadth, 11 mm.; of the foot, 66 mm.; between lateral tips, 38 mm. Projection of digit III beyond the others, 16 mm. Divarication of digits I and II, 90°; of II and III, 40°; of III and IV, 50°; of the lateral digits, II and IV, 87°.

Length of pace, 100 mm.; width of trackway, 115 mm.

Ratio of foot to pace, as 1 to 1.51.

Pes angle, $\pm 0^\circ$. Interpes distance, 70 mm. between axes of foot.

A very short-legged, wide-bodied animal.

Localities:—Field's orchard and Ferry at Gill; Turners Falls, north bank below Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Xiphopeza triplex* resembles *Sillimanius tetradactylus* quite closely except for size, the latter averaging twice as large. The heel of *Xiphopeza*, on the other hand, is relatively longer, the body seems to have had greater breadth, and the evidence of a manus in *Sillimanius* is lacking.

Genus *Tarsodactylus* E. Hitchcock

E. Hitchcock 1858, p. 98.

Lull 1904A, p. 526; 1915, p. 243.

Generic Characters:—Quadrupedal, digitigrade. Manus, penta-



FIGURE 137.

Tarsodactylus trackway, original, one-fourth natural size.

dactyl; pes, tetradactyl, with broad digits and both phalangeal pads and somewhat acuminate claws. Tail trace may be in evidence.

But two species of *Tarsodactylus*, *T. caudatus*, the genotype, and *T. expansus*, have been described; the latter not figured.

Tarsodactylus caudatus

E. Hitchcock

E. Hitchcock 1858, p. 99, pl. 17, fig. 4; pl. 36, fig. 2.

Lull 1904A, p. 527; 1915, p. 244, fig. 101.

Holotype.—Cat. No. 42/5 A. C., on a slab of hard shale, from Turners Falls, Mass.

Specific Description.—Manus: Pentadactyl, digitigrade, digits with rounded tips. Length of digit I, 14 mm.; of II, 19 mm.; of III, 18 mm.; of IV, 11.5 mm.; of V, 9 mm. Length of entire manus, 40 mm.; its breadth, 37 mm. Divarication of digits I and II, 24°; of II and III, 21°; of III and IV, 21°; of IV and V, 15°; of I and V, 81°.

Pes: Tetradactyl, plantigrade. Digit III clawed, digits II and IV with rounded, pellet-like nails. Phalangeal pads impressing. Length of digit II, 32 mm.; of III, 51 mm.; of IV to rear of heel, 54 mm.; of the foot, 80 mm.; between lateral tips, 46 mm. Projection of digit III beyond the others, 28 mm. Divarication of digits I and II, 74°; of II and III, 18°; of III and IV, 22°; of the lateral digits, II and IV, 42°.

Length of the pace, 130 to 178 mm., average 153 mm. Width of trackway, 178 mm. Ratio of foot to average pace, as 1 to 1.91.

Tail trace nearly straight, rarely more than 2 mm. wide; interrupted.

Pes angulation as much as 20°, inward. Manus, outward several degrees.

Pace angulation, about 70°. Interpes distance, 114 mm.

Localities.—Lily Pond, Gill; Turners Falls, Mass.

Geological Distribution.—Upper (Portland) series.

***Tarsodactylus expansus* C. H. Hitchcock**

C. H. Hitchcock 1866, p. 301 (no figure).

Lull 1904A, p. 527; 1915, p. 244.

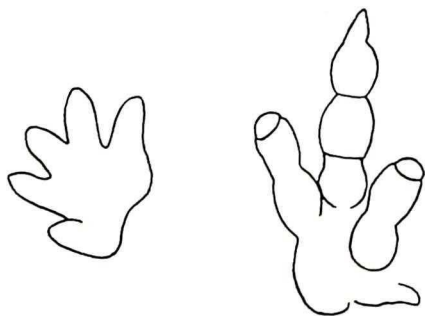


FIGURE 138.

Tarsodactylus caudatus Hitchcock, after Lull, one-half natural size.

Holotype:—Cat. No. 5102, Dartmouth College Museum¹.

Specific Characters:—Manus: Pentadactyl, pachydactylous. Length of digit I, 12 mm.; of II, 20 mm.; of III, 19 mm.; of IV, 15 mm.; of V, 9 mm.; between lateral tips, 25 mm. Divarication of digits I and II, 30°; of II and III, 20°; of III and IV, 25°; of IV and V, 25°–30°; of I and V, 100°. Manus angulation, outward on the right, forward on the left.

Pes: Tetradactyl; three toes pointing forward; hallux touching only at its extremity on the inner side of the heel near the base of the forward toes. Length of digit I, 5 mm.; of II, 25 mm.; of III, 36 mm.; of IV, 29 mm. Projection of digit III, beyond the other toes, 16 mm. Length of the foot, 43 mm.; between lateral tips, 38 mm. Divarication of digits II and III, 25°; of III and IV, 50°; of the lateral digits, II and IV, 75° to 80°.

Length of the pace, 50 to 113 mm.; of the stride, 126 to 178 mm. Width of the trackway, 140 mm. Ratio of foot to average pace, as 1 to 1.9.

Pes angulation, 20° to 25° inward. Interpes distance, 50 to 75 mm.

Locality:—Ferry above Turners Falls, near Greenfield, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—C. H. Hitchcock says of *T. expansus*: "It differs from *T. caudatus* * * * in the greater divarication * * * of the toes; its inferior size, being from one fourth to one half smaller, and thirdly, its mode of progression is irregular and it does not trail its claws in the mud. * * * The front feet, of the two species appear to correspond perfectly except in size."

Group XI. Habitually quadrupedal. Pes, plantigrade, tridactyl to pentadactyl; manus, pentadactyl, generally deeply impressed.

Pes: Generally short; trackway medium to very wide. Sprawling gait.

Genera: *Chelonoides*, *Arachnichnus*, *Sustenodactylus*.

Genus *Chelonoides* E. Hitchcock

E. Hitchcock 1858, p. 140.

Lull 1904A, p. 529; 1915, p. 248.

Generic Characters:—Quadrupedal, pes tridactyl, digitigrade, smaller than the manus; without phalangeal pads or distinct claws. Manus pentadactyl; plantigrade with distinct heel. Limbs long, body wide.

Discussion:—Hitchcock likened these tracks to those of a chelonian, hence the generic name; but the feet are not turtle-like and the pace

¹Note: This specimen is too obscure to be the type; the dimensions given are those of C. H. Hitchcock.

is much too long. The width of the trackway might be considered a chelonian character, but there seems to be no other, and this factor will hardly imply relationship for it is true of other reptiles and amphibians.

But one species, *Chelonoides incedens*, the genotype, has been described.

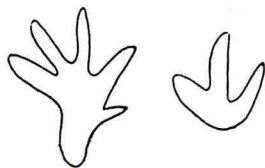


FIGURE 139.
Chelonoides incedens
Hitchcock, after Hitchcock,
from type Cat. No. 6/1 A. C.
one-half natural size.

Chelonoides incedens E. Hitchcock

E. Hitchcock 1858, p. 140, pl. 31, fig. 3.

Lull 1904A, p. 529; 1915, p. 248, fig. 106.

Holotype.—Cat. No. 6/1 A. C. Large slab from the Lily Pond, Gill, Mass., containing the footprints of at least six species. The only recorded locality of *Chelonoides*.

Specific Characters.—Manus: Length of digit I, 10 mm.; of II, 18 mm.; of III, 22 mm.; of IV, 20 mm.; of V, 20 mm.; of the hand, 40 mm.; of the heel, 18 mm. Divarication of digits I and II, 44° ; of II and III, 35° ; of III and IV, 37° of the lateral digits, II and IV, 95° .

Pes: Length of digit II, 13 mm.; of III, 20 mm.; of IV, 17 mm.; of the foot, 26 mm.; between lateral tips, 25 mm. Divarication of digits II and III, 50° ; of III and IV, 27° ; of the lateral digits II and IV, 80° .

Length of the pace, 220 mm.; of the stride, 355 mm. Width of trackway, 165 mm. Ratio of foot to pace, as 1 to 8.46.

Pes angle, about 0° .

A very rare form. But two specimens recorded in the Amherst collection in 1858.

Discussion.—Hitchcock expresses some doubt as to which track represents the manus and which the pes in this rare species, but as the smaller three-toed track is always behind the other he assumed it to be the hind foot. The matter seems quite questionable and further material is essential to its final acceptance. One feels that the tracks are reversed in the description.

Genus *Arachnichnus* E. Hitchcock

E. Hitchcock 1858, p. 117.

Lull 1904A, p. 538; 1915, p. 261.

Generic Characters.—Small, quadrupedal, plantigrade forms. Limbs moderately long, body wide. Digits slender, without phalangeal pads

or definite claws. Manus tetradactyl, pes also but bearing a vestigial fifth digit.

But one species, *Arachnichnus dehiscens*, has been described, which becomes the genotype.

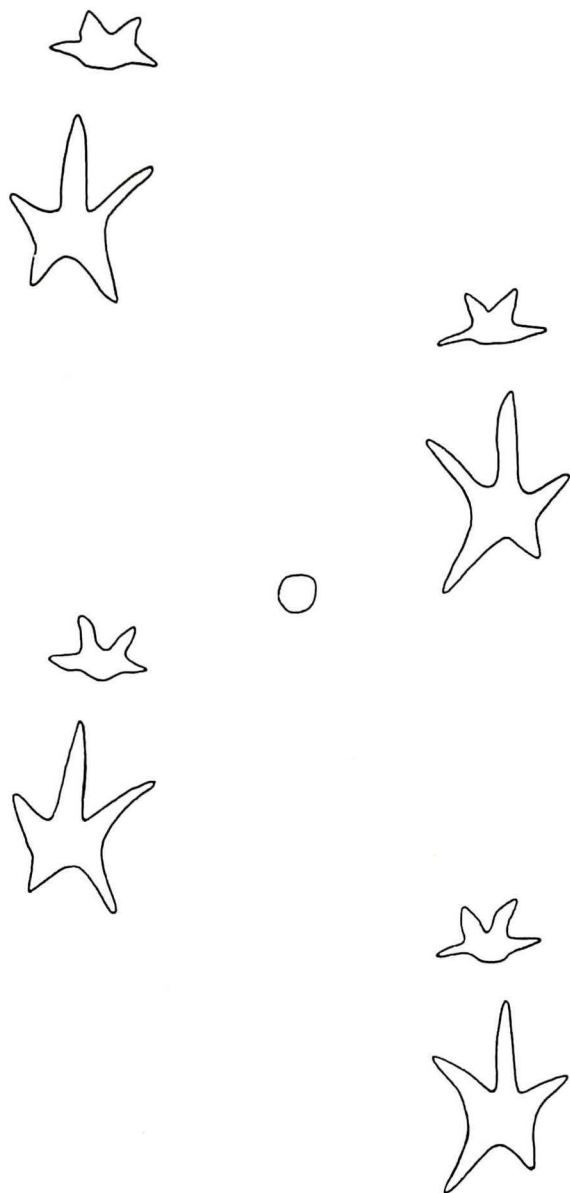


FIGURE 140.
• *Arachnichnus* trackway, original, natural size.

Arachnichus dehiscens, E. Hitchcock

E. Hitchcock 1858, p. 117, pl. 20, figs. 12-13; pl. 37, fig. 2; 1865, p. 24, pl. 17, fig. 2.

Lull 1904A, p. 539; 1915, p. 261, fig. 122.

Holotype.—Cat. No. 51/18 A. C., from the Lily Pond, Gill, Mass. In the original description of this species no type is indicated, but a number of specimens are mentioned, Nos. 40/12, 40/13, 40/11, 40/15, and 40/62. In the redescription in 1865, Hitchcock designates the specimen 51/18 as the type.



FIGURE 141.

Arachnichus dehiscens
Hitchcock, after Lull,
from the type Cat.
No. 51/18 A. C.
natural size.

Specific Characters.—Manus: Length, 9 mm.; breadth, 13 mm. Divarication of lateral digits, 180° .

Pes: Length of digit I, 10 mm.; of II, 11 mm.; of III, 14 mm.; of IV, 7.5 mm. Length of foot, 28 mm.; between lateral tips, 19 mm. Divarication of digits I and II, 106° ; of II and III, 43° ; of III and IV, 54° ; of the lateral digits, II and IV, 85° .

Length of the pace, about 40 mm.; of the stride, 76 to 114 mm. Width of the trackway, 76 mm. Ratio of foot to average stride, as 1 to 3.4; to average pace, as 1 to 2.14.

Pes angulation, 0° .

Localities.—Lily Pond, Horse Race, Gill, below dam at Turners Falls, South Hadley, Mt. Tom East, Easthampton, Mass.; southwest part of Middletown and Wethersfield, Conn.

Geological Distribution.—Upper (posterior) shales and Upper (Portland) series.

Genus *Sustenodactylus* Lull

Stenodactylus E. Hitchcock 1858, p. 116.

Lull 1904A, p. 537 (for *Stenodactylus* preoccupied); 1915, p. 258.

Generic Characters.—Quadrupedal, digitigrade to semi-plantigrade. Both fore and hind feet pentadactyl. Digits very slen-

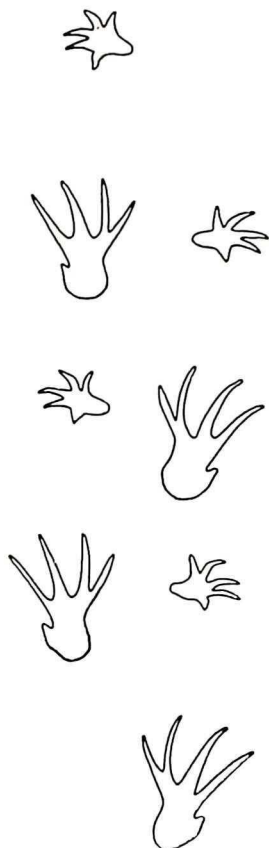


FIGURE 142.

Sustenodactylus trackway,
original, one-half natural size.

der and tapering; without phalangeal pads or definite claws. Pes about twice the size of the manus.

But one species has been described, *S. curvatus*, which is therefore the genotype.

***Sustenodactylus curvatus* (E. Hitchcock)**

Stenodactylus curvatus E. Hitchcock 1858, p. 116, pl. 20, fig. 11; pl. 34, fig. 3.

Lull 1904A, p. 537; 1915, p. 258, fig. 118.

Holotype.—Cat. No. 34/43 A. C. (No. 34/30 of the Ichnology, 1858). Shale with two rows of tracks, from Turners Falls, Mass., on Field's farm.

Specific Characters.—Toes of both manus and pes turned outward from the median line.

Manus: Length of digit I, 6 mm.; of II, 7 mm.; of III, 12 mm.; of IV, 14 mm.; of V, 2 mm. Divarication of the lateral digits I to V, 180°. Manus angulation, 90° outward. Inter-manus distance (heels), 30 to 56 mm.

Pes: Length of digit I, 18 mm.; of II, 20 mm.; of III, 30 mm.; of IV, 21 mm.; of V, 6 mm.; of the foot, 34 mm. Between lateral tips, 28 mm. Divarication of the lateral toes, I and IV, 70°.

Length of stride (same foot), 90 mm.; of the pace, 67 mm. Width of the trackway, 64 mm.

Ratio of foot to pace, as 1 to 2.

Pes angle, about 20° outward. Inter-heel distance, 30 mm.

Manus rarely less than 25 mm., in advance of the pes.

Locality.—Turners Falls, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion.—*Sustenodactylus* is a short-legged slender-toed quadrupedal form, more amphibian than reptilian in character.

Group XII. Quadrupedal.

Pes: Digitigrade, tetradactyl.

Manus: Tetradactyl, or pentadactyl. Tracks abnormal, due apparently to slippage.

Genera: *Orthodactylus*, *Isocampe*.



FIGURE 143.
Sustenodactylus curvatus
(Hitchcock), after Lull,
natural size.

Genus *Orthodactylus* E. Hitchcock

E. Hitchcock 1858, p. 113.

Lull 1904A, p. 535; 1915, p. 256.

Generic Characters:—Quadrupedal, digitigrade forms; fore and hind feet unequal in size and otherwise unlike. Hind foot with four, long, straight, narrow digits, diverging but little, clawless and without phalangeal pads. Fore foot with four or five short digits ranging through 180° or more of divarication. Fore foot imprint just in advance of that of the hind foot.

Three species of *Orthodactylus* have been described: *O. floriferus*, the genotype, together with *O. intro-vergens* and *O. linearis*.

They are all from the Turners Falls region of Massachusetts and therefore from the Upper (Portland) series.



FIGURE 144.
Orthodactylus
floriferus Hitchcock,
after Lull,
natural size.

Orthodactylus floriferus E. Hitchcock

E. Hitchcock 1858, p. 114, pl. 20, fig. 7; pl. 45, fig. 2.

Lull 1904A, p. 535; 1915, p. 256, fig. 114.

Holotype:—Cat. No. 6/1 A. C., on a large slab, in association with at least six other genera and species. From the Lily Pond, Gill, Mass.

Specific Characters:—Manus: with five subequal digits, about 10 mm. in length.; rather thick and with acuminate claw-like tips. Divarication of digits, through 180° .

Pes: Length of digit I, 15 mm.; of II, 20 mm.; of III, 21 mm.; of IV, 18 mm. Length of the foot, about 25 mm. Between lateral tips, 13 mm. Divarication of digits I and II, 12.5° ; of II and III, 4° ; of III and IV, 9.5° ; of the lateral digits I and IV, 25° .

Length of the pace, 45 to 63 mm. Of the stride, 73 to 81 mm.; width of trackway, 82 mm. Ratio of foot to average pace, as 1 to 2.16.

Pes angulation, 33° to 40° outward.

Interpes (mid-heels) distance, 15 to 45 mm.

The hind feet of the right side of the trackway only are known and the toes seem to have been unduly lengthened in the track due to slippage. The entire heel is not impressed so that the length of the foot is questionable, due to these two factors.

Localities:—Lily Pond, Gill, and Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Orthodactylus intro-vergens E. Hitchcock

E. Hitchcock 1858, p. 114, pl. 20, fig. 8; pl. 51, fig. 1.

Lull 1904A, p. 535; 1915, p. 256, fig. 115.

Cotypes.—Cat. No. 34/32 A. C., on red shale, with seven hind foot and one fore foot impressions, from Turners Falls, Mass., and Cat. No. 32/50, from the same locality.

Specific Characters.—Manus: digits, five, somewhat curved, ranging through 280° of divarication. Manus: about half the length of the pes.

Pes: With three, probably four toes; digits long, slender and straight. Length of digit II, 34 mm.; of III, 35 mm.; of IV, 20 mm.; of the foot, 37 mm.; between lateral tips, 25 mm.

Divarication of digits II and III, 5° ; of III and IV, 20° ; of the lateral digits, II and IV, 26° .

Length of stride, 54 mm.; width of trackway, 83 mm.

Ratio of foot to stride, as 1 to 1.47.

Pes angulation, a few degrees inward.

Localities.—Field's orchard and Lily Pond in Gill, and Turners Falls, Mass.

Geological Distribution.—Upper (Portland) series.

Discussion.—Hitchcock's distinction between *O. floriferus* and *O. intro-vergens* is largely one of pes angulation for in the former the angulation is outward and in the latter inward, hence the specific name. The contrast between the number of pedal digits, four and three, is probably accidental in the footprints and not significant. The material on which the present species is based is rare and hardly satisfactory, but Hitchcock's figures are evidently specifically distinct.



FIGURE 145.

Orthodactylus intro-vergens
Hitchcock, after Hitchcock,
from the type Cat. No.
34/32 A. C. natural size.

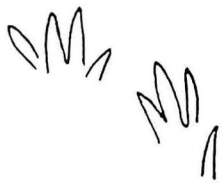


FIGURE 146.

Orthodactylus linearis
Hitchcock, after Hitchcock,
from the type Cat. No.
27/15 A. C. natural size.

Orthodactylus linearis E. Hitchcock

E. Hitchcock 1858, p. 115, pl. 20, fig. 9; pl. 48, fig. 4.

Lull 1904A, p. 536; 1915, p. 257, fig. 116.

Holotype.—Cat. No. 27/15 A. C. On red shale from Turners Falls, Mass., the only recorded locality.

Specific Characters.—Manus tetradactyl,

apparently similar to the pes, though more slender, but the specimens are too indistinct for a detailed description.

Pes: Digits ranging in length from 7 mm. to 13 mm.; nearly parallel, the total divarication not exceeding 20° . "Toes increasing in length outwardly excepting perhaps the last" (E. Hitchcock).

Length of stride, 43 mm. Width of trackway, 38 mm.

Locality:—Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—The manus and pes are so similar in Hitchcock's figure that they may both be of the hind foot. The typical fore foot of the other *Orthodactylus* species with its widely radiating digits and much smaller size as compared with the pes is not in evidence.

The species is ill defined and therefore questionable.

Genus *Isocampe* E. Hitchcock

E. Hitchcock 1858, p. 119.

Lull 1904A, p. 537; 1915, p. 259, fig. 119.

Generic Characters:—Quadrupedal, tetradactyl, digitigrade. Manus and pes unequal in size; digits of the manus nearly straight, divergent; those of the pes curved inward toward the median line and nearly parallel. Digits without phalangeal pads or claws.

Caudal trace may be present. Short-limbed, broad-bodied forms.

But one species, *Isocampe strata* E. Hitchcock, has been described, and becomes the genotype.

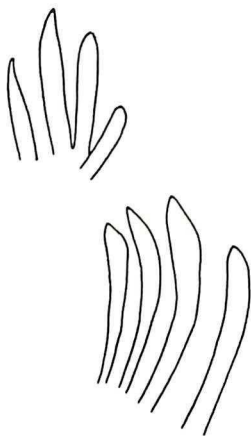


FIGURE 147.

Isocampe strata Hitchcock, after Hitchcock, from the type Cat. No. 40/62 A. C. one-half natural size.

Isocampe strata E. Hitchcock

E. Hitchcock 1858, p. 120, pl. 20, fig. 5; pl. 36, fig. 5.

Lull 1904A, p. 537; 1915, p. 259, fig. 119.

Cotypes:—Cat. No. 40/62 A. C., from Turners Falls, Mass., and No. 26/4 on red sandstone, from Portland, Conn.

Specific Characters:—Manus: Length of digit I, 27 mm.; of II, 42 mm.; of III, 30 mm.; of IV, 27 mm. Divarication of digits I and II, 5° ; of II and III, 5° ; of III and IV, 25° ; of the lateral digits, I and IV, 35° . Manus angle a little more inward than that of the pes. Position of manus a little in front of and within that of the pes.

Pes: Length of digit I, 41 mm.; of II,

50 mm.; of III, 58 mm.; of IV, 54 mm. Digits nearly parallel. Pes angle nearly 0° .

Interpes distance between axes of feet, 110 to 162 mm.

Stride, of the same foot, 85 mm.; width of trackway, 178 mm.

Tail trace broad, crooked, irregular.

Localities:—Turners Falls, Mass., and Portland, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion:—These footprints are evidently characterless of the true morphology of the feet, owing to the slippage of both manus and pes so that the linear dimensions of the actual toes seem to have been exaggerated; how much one cannot tell.

Group XIII. Miscellaneous, obscure forms.

Genera: *Amblypus*, *Ancyropus*, *Antipus*, *Trienopus*, *Typopus*, *Cunichnoides*.

Genus *Amblypus* E. Hitchcock

E. Hitchcock 1858, p. 143.

Lull 1904A, p. 530; 1915, p. 249.

Generic Description:—Small forms. Manus: unknown. Pes: plantigrade, tridactyl, with the digits compacted together and curving inward; the foot as a whole turns outward.

Discussion:—A curious feature of this form is that in the several known specimens, with a single exception, the right foot only is seen. The Yale imprints are all of the right foot only. This fact has suggested the specific name. The reason may be that the animal was walking across the strike of an inclined surface which caused the greater part of its weight to bear on the right foot, the left leaving little or no trace on the sediment.

But one species, *Amblypus dextratus*, the genotype, has been described.

Amblypus dextratus E. Hitchcock

E. Hitchcock 1858, p. 143, pl. 25, fig. 7; pl. 48, fig. 5.

Lull 1904A, p. 530; 1915, p. 249, fig. 107.

Holotype:—Cat. No. 34/27 A. C., on black shale, from Turners Falls, Mass.

Specific Characters:—Pes: plantigrade, ovoid in outline with but three toes closely compressed together, the lateral ones with pointed tips, the middle toe apparently incomplete on the track. No trace of phalangeal pads or distinct claws. Length of the inner digit, II, about 7



FIGURE 148.
Amblypus dextratus
Hitchcock,
after Hitchcock,
from the type Cat.
No. 34/27 A. C.
natural size.

mm.; of III, 6 mm.; of IV, 8 mm. Length of the foot, 25 mm.; of the heel, 12.5 mm. Breadth of the foot, 13 mm.

Length of the stride, 100 to 113 mm.; width of the trackway, 100 mm. Ratio of foot to stride, as 1 to 4.

Pes angulation inward ?

Interpes distance, 45 mm.

Locality:—Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Genus *Ancyropus* E. Hitchcock

E. Hitchcock 1845, p. 24; 1848, p. 242; 1858, p. 138.

Lull 1904A, p. 528; 1915, p. 247.

Generic Description:—Quadrupedal, plantigrade; Manus and pes similar in general form and of nearly equal length but the manus is much the more slender.

Pes: Tetradactyl with the three front toes nearly parallel, acutely tapering, and bending strongly outward. The first toe (hallux) arises toward the rear of the broad, curved sole of the foot, and nearly at right angles with its axis. *Manus*: tridactyl with the same s-curved form and posterior projection as the pes. No claws or phalangeal pads present in the tracks.

But one species, *A. heteroclitus*, has been described, hence is the genotype.

Hitchcock compares *heteroclitus* to the hind foot of the New Holland turtle depicted on pl. 21, fig. 2 of Duméril et Bibron, *Atlas d'Erpétologie Générale* (1854). The likeness is suggestive except that the turtle has four anterior digits with long curved claws, and the sole of the foot is relatively shorter. The curious projection at the rear toe. There is no resemblance between the manus of the turtle and the slenderer track.

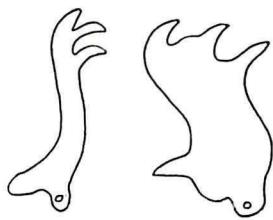


FIGURE 149.
Ancyropus heteroclitus
(Hitchcock), after Hitchcock,
from the type Cat. No.
27/7 A.C. one-half natural size.

Ancyropus heteroclitus (E. Hitchcock)

Sauroidichnites heteroclitus and *jacksoni*, E. Hitchcock 1841, p. 478, pl. 30, figs. 2,3.

E. Hitchcock 1845, p. 24; 1848, p. 243, pl. 15, figs. 3-5; 1858, p. 139, pl. 25, figs. 3,4; pl. 53, figs. 1,2.

Ancyropus jacksonianus E. Hitchcock 1845, p. 24.

Lull 1904A, p. 529; 1915, p. 247, fig. 105.

Holotype:—Cat. No. 27/7 A. C., on gray shale from Wethersfield, Conn.

Specific Characters:—Manus: Length 50 mm.; average length of digits, 7 to 8 mm.; breadth of palm, 7 mm.

Pes: Length of foot, 52 mm.; breadth across digits, 33 mm.; across sole, 20 mm. Average length of digits, about 10 mm. Hallux far back, at right angles with axis of foot. Pes angle, about 0°

Length of step, 63 mm. Width of trackway, 165 mm.

Localities:—Lily Pond, Gill, north bank below Turners Falls, ? Moody's corner, Mass.; Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion:—In 1841, Hitchcock described these two tracks under separate specific names. To the stouter tetradactyl form he gave the name *heteroclitus* and to the slender, tridactyl track that of *jacksoni*, remarking under the description of the latter "that it is possible that it may be a variety of that [*heteroclitus*] species." Later in 1845, he redescribes the species under the original name of *heteroclitus* referring to the more slender *jacksoni* track as the fore foot of *heteroclitus*. They are both more pes- than manus-like and may represent an age or sex variation of which the broader track is the more typical. It may have been made by a chelonian as Hitchcock thought.

Genus *Antipus* E. Hitchcock

E. Hitchcock 1858, p. 115.

Lull 1904A, p. 536; 1915, p. 257.

Generic Characters:—Quadrupedal, digitigrade. Pes tetradactyl, manus pentadactyl, without phalangeal pads or separate claws.

Discussion:—The apparent peculiarity of this genus to which the name *Antipus* refers is that the impressions of manus and pes point in opposite directions, which may be observed in the arrested gait of certain modern lizards and amphibians, and is therefore not generically distinctive. Aside from this feature the tracks resemble somewhat those of other genera, such as *Sustenodactylus*.

Two species have been described by Hitchcock, *Antipus flexiloquus*, the genotype, and *A. bifidus*; of these the former only seems to have validity.

Antipus flexiloquus E. Hitchcock

E. Hitchcock 1858, p. 115, pl. 20, fig. 10.

Lull 1904A, p. 536; 1915, p. 258, fig. 117.

Holotype:—Cat. No. 41/52 A. C., from Turners Falls, Mass.

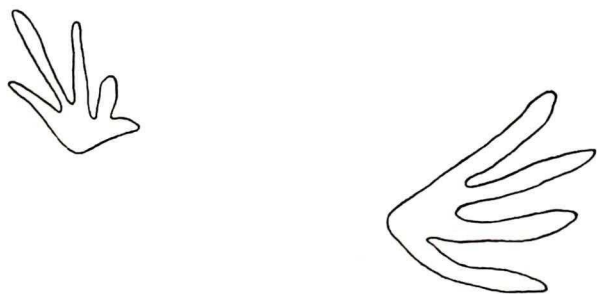


FIGURE 150.

Antipus flexiloquus Hitchcock, after Hitchcock, from the type Cat. No. 41/52 A. C. natural size.

Specific Characters:—Manus: Pentadactyl, toes very narrow and nearly straight. Axis of the hand turned outward from the median line, 60° to 70° . Length of digit I, 15 mm.; of II, 20 mm.; of III, 16 mm.; of IV, 15 mm.; of V, 10 mm. Length of hand, 23 mm. Divarication of the outer toes, 130° .

Pes: Tetradactyl, toes narrow, acuminate, curved, all pointing backward in the track and somewhat outward. Length of digit I, the outermost in the impression, 18 mm.; of II, 20 mm.; of III, 20 mm.; of IV, 19 mm. Length of the foot, 29 mm.; between the lateral tips, I and IV, 25 mm. Divarication of the lateral digits, 60° .

Length of the stride, 38 to 84 mm.; width of the trackway, 127 mm. Ratio of foot to average stride, as 1 to 2.1.

Locality:—Turners Falls, Field's farm, Lily Pond, Gill, Mass.

Geological Distribution:—Upper (Portland) series.

Antipus bifidus E. Hitchcock

E. Hitchcock 1858, p. 116, pl. 36, fig. 8; pl. 48, fig. 10.

Holotype:—Cat. No. 23/2, A. C., from the Ferry at Turners Falls, Mass.

Specific Description:—(After Hitchcock) "Hind Foot?—Didactylous; outer toe 7 inches [180 mm.] long; inner toes 12 inches [305 mm.]; width 1.25 inches [31 mm.]; blunt. Angle between them 20° . Toes seeming like a simple bifurcation of the heel. Fore foot and hind foot 8 inches [204 mm.] Trace of a narrow tail on the inner or left hand side of the tracks. Width of the trackway 11 inches [280 mm.]."

"Fore Foot?—Inner toe 5 inches long [126 mm.]; outer toe 12 inches [305 mm.]; angle between them 15° ; width of the toes 1.25 inches [31 mm.]. Toes blunt."

Locality:—Ferry at Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—*Antipus bifidus* is a very questionable species for, judging from Hitchcock's figure (pl. 36, fig. 8), no morphological characters are discernible.

Genus *Triænopus* E. Hitchcock

E. Hitchcock 1845, p. 24 (name without definition); 1848, p. 202; 1858, p. 111.

Lull 1904A, p. 539; 1915, p. 261.

Generic Characters:—Bipedal or quadrupedal, tetradactyl, plantigrade. Toes long and slender, without phalangeal pads or distinct claws. Three toes directed forward, with little divarication; the small hallux arising from near the extremity of the heel.

Discussion:—This genus has been described by Hitchcock as being, first, the imprints of two bipeds and later as a quadruped with very similar feet, neither of which has distinctive manus-like characters. This is similar to Hitchcock's original conception of *Plesiornis* which he also defines as a quadruped with little or no distinction between fore and hind feet, except for their relative size and apparent position in the trackway. The discovery of a true manus-like imprint in association with that of the pes will be final proof of the bipedal gait, but as in the bipedal genus *Anchisauripus*, known by hundreds of pes impressions, and not one associated manus track, this proof may never be forthcoming.

Two species of *Triænopus* are recognized: one, *T. emmonsii* E. Hitchcock, the genotype, from the upper (Portland) series, and the other, *T. lulli* Thorpe, from the upper (posterior) shales of North Branford, Conn.

Triænopus emmonsii (E. Hitchcock)

Sauroidichnites emmonsii E. Hitchcock 1841, p. 479, pl. 30, fig. 4; pl. 31, figs. 5, 6.

Sauroidichnites baileyi E. Hitchcock 1841, p. 480, pl. 32, figs. 8-10.

Triænopus baileyanus E. Hitchcock 1845, p. 24; 1848, p. 203, pl. 10, fig. 4. Lull 1904A, p. 534.

Triænopus emmonsianus E. Hitchcock 1845, p. 24; 1848, p. 204, pl. 10, fig. 5.

Triænopus leptodactylus E. Hitchcock 1858, p. 111, pl. 19, figs. 1-9; pl. 20, figs. 1-3; pl. 45, fig. 8; pl. 52, fig. 1.

Triænopus baileyi Lull 1915, p. 262, fig. 123.

Holotype:—Cat. No. 31/27 A. C., on red shale, from Wethersfield, Conn.

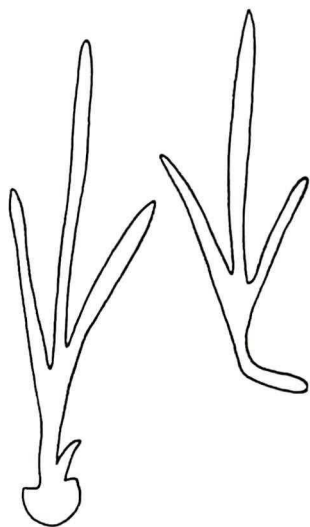


FIGURE 151.

Trianopus emmonsii
(Hitchcock), after Hitchcock,
from the type Cat. No. 31/27
A.C. one-half natural size.

Specific Characters:—"Manus": Length of digit I, 18 to 25 mm.; of II, 38 to 51 mm.; of III, 60 to 80 mm.; of IV, 38 to 55 mm.; of the hand, 70 to 100 mm.; between lateral tips, 38 to 51 mm. Divarication of digits II and III, 25°; of III and IV, 25°; of II and IV, 50°.

This is the footprint originally described as *T. emmonsii*.

Pes: Length of digit I, 18 to 22 mm.; of II, 40 to 56 mm.; of III, 63 to 90 mm.; of IV, 50 to 63 mm. Projection of digit III beyond the other toes, 37.5 mm. Length of the foot, 100 to 125 mm.; of the heel, 35 to 50 mm.; between the lateral tips, 35 to 49 mm. Divarication of digits II and III, 15° to 20°; of III and IV, 15° to 20°; of the lateral digits, II and IV, 35° to 40°.

Length of the pace, about 180 mm.; width of the trackway, 63 mm. Ratio of foot to pace, as 1 to 1.7.

This is the footprint described as *T. baileyi*.

Locality:—Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion:—The complicated synonymy of this species is due to the fact that Hitchcock first described the tracks in 1841 as pertaining to two species, to which he gave the names *Sauroidichnites emmonsii* and *S. baileyi*, the first being on the preceding page. Later he referred them to a new genus *Trianopus* giving *baileyanus* page precedence. In 1858, however, having by this time decided that they constituted one quadrupedal form, although with some misgivings, he gave it a new specific name, *leptodactylus*, referring to his old species *emmonsii* as the fore foot and *baileyi* as the hind foot. As the specific name *emmonsii* is the first described, it has priority over the other two and must stand as that of this form. As the so-called manus is so very pes-like and so very similar to the described pes, the writer is inclined to consider their distinction largely a matter of individual variation, and to believe that each represents the hind foot track of a bipedal creature of which the real manus track is as yet unknown.

Trianopus lulli Thorpe

Thorpe 1929, p. 299, fig. 9.

Holotype:—Cat. No. 1217 Y. P. M., red sandstone slab with

a single relief track of the left pes. Also No. 1225 Y. P. M. Both from Sugar Loaf Tunnel, North Branford, Conn.

Specific Characters.—Pes: tetradactyl, plantigrade, with three slender anterior digits showing neither phalangeal pads nor claws. Hallux short, on the medial side of the heel, 26 mm. from the posterior end. Heel elongate, about twice the width of the third digit, dilating into a conspicuous hump at its terminus.

Dimensions: Length of digit I, 11 mm.; of II, 60 mm.; of III, 106 mm.; of IV, 65 mm.; projection of digit III beyond the others, 52 mm. Length of foot, 176 mm.; of the heel, 70 mm. Breadth of posterior end ("hump"), 34 mm.; between lateral tips, 84 mm. Divarication of digits II and III, 36° ; of III and IV, 36° ; of II and IV, 70° .

Length of stride, 608 mm. Ratio of foot to estimated pace, as 1 to 1.8, from three prints on the roof of the tunnel which could not be removed.

Locality.—North Branford, Conn.

Geological Distribution.—Upper (posterior) shales.

Discussion.—*Trienopus lulli* is a larger form than *T. emmonsii* and differs from it in the shape of the rear of the heel which in the latter species is generally but not always pointed and not blunt as in *lulli*. The ratio of foot to pace is apparently similar in the two species but the stratigraphic element is important.

Genus *Typopus* E. Hitchcock

E. Hitchcock 1845, p. 25; 1848, p. 212; 1858, p. 105.

Lull 1904A, p. 542.

Generic Characters.—Bipedal, tridactyl or tetradactyl tracks, so aberrant that the morphology of the feet of the animals that made them is quite obscure. Heel a groove nearly at right angles with the

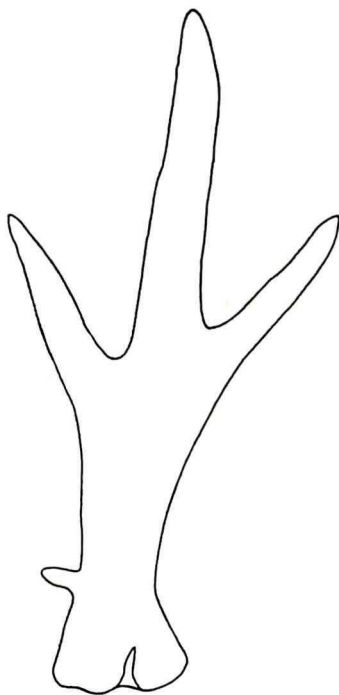


FIGURE 152.

Trienopus lulli Thorpe, modified
from Thorpe, Cat. No. 1217 Y. P. M.
one-half natural size.

axis of the foot from which three anterior toes seem to arise and a backward prolongation of one end of the heel, possibly a fourth toe. Semi-plantigrade, digits slender with neither phalangeal pads nor distinct claws.

Two species have been described: *Typopus abnormis*, the genotype, and *T. gracilis*, both by Edward Hitchcock.

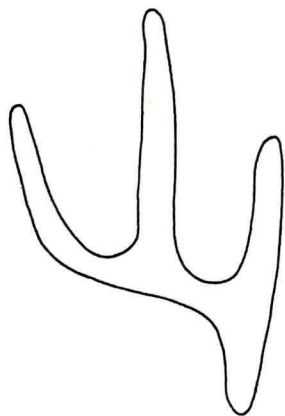


FIGURE 153.

Typopus abnormis (Hitchcock),
after Hitchcock, from the
type Cat. No. 19/1 A.C.
one-half natural size.

Projection of middle toe beyond the others, 35 mm. Divarication of digits II and III, 20° to 15°; of III and IV, 15° to 18°; of the lateral digits, II and IV, 30° to 35°.

Length of pace, 45.7 mm. Width of trackway unrecorded. Ratio of foot to pace, 1 to 4.57.

Pes angulation, left foot, 15°; right foot, 30° inward.

Distance between axes of feet, 126 mm.

Locality:—Above Turners Falls in Gill, Mass.

Geological Distribution:—Upper (Portland) series.

Typopus gracilis E. Hitchcock

E. Hitchcock 1848, pl. 15, fig. 4 (figured without description); 1858, p. 106, pl. 17, fig. 10.

Lull 1904A, p. 243.

Holotype:—Cat. No. 31/46 A.C., on red shale from Wethersfield, Conn.

Specific Characters:—Three toes pointing forward, the second apparently arising from the third at mid-length and the backward pro-

Typopus abnormis (E. Hitchcock)

Sauroidichnites abnormis E. Hitchcock
1844, p. 307, pl. 3, figs. 6,7,8 (last showing
4 steps).

E. Hitchcock 1845, p. 25; 1848, p. 212,
pl. 10, fig. 6; 1858, p. 105, pl. 17, fig. 9;
pl. 45, fig. 7.

Lull 1904A, p. 543.

Cotypes:—Cat. Nos. 19/1, and 19/2
A.C., on fine gray, micaceous sandstone,
with four impressions of *Typopus abnor-*
mis, from the Ferry at Turners Falls, Mass.

Specific Characters:—Pes: Length of
digit II, 35 mm.; of III, 70 mm.; of IV,
50 mm.; of the foot, 100 mm.; between
lateral tips, 70 mm. Width of transverse
portion of heel mark, 50 mm.; length of
backward prolongation of heel, 17 mm.

longation of the heel mark terminating in a point as though it were a digit.

Length of digit II, 20 mm.; of III, 35 mm.; of IV, measured on the chord of a much curved toe, 27 mm. Length of the foot, 60 mm. Width of transverse portion of heel, 27 mm. Length of backward prolongation, 18 mm.

An isolated track.

Locality:—Wethersfield, Conn.

Geological Distribution:—Upper (Portland) series.

Discussion: This track is apparently distorted, for it shows no understandable morphology. It differs from *T. abnormis* not only in being smaller but in its more complicated form. Digits II and III apparently arise from the transverse portion of the heel as one, which bifurcate to form the digits (see figure 154); compare *Toxichnus inaequalis* (Fig. 77).



FIGURE 154.

Typopus gracilis
Hitchcock, modified
from Hitchcock, from
the type Cat. No.
31/46, A. C.
one-half natural size.

Genus *Cunichnoides* E. Hitchcock

E. Hitchcock 1858, p. 54.

Generic Characters:—(After Hitchcock): "Quadrupedal; fore feet rather the smallest. Ball of the foot making a distinct impression in the mud, with at least four circular impressions arranged nearly on a semi-circle in front of that made by the ball."

But one species of this rare track has been described, *C. marsupialoideus*, the genotype.

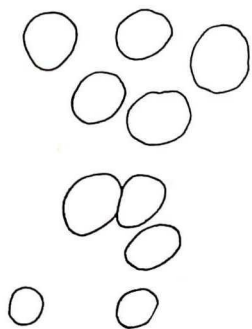


FIGURE 155.

Cunichnoides marsupialoideus
Hitchcock, after Hitchcock,
from the type Cat. No. 29/2
A. C. one-half natural size.

Cunichnoides marsupialoideus E. Hitchcock

E. Hitchcock 1858, p. 55, pl. 9, fig. 5; pl. 60, fig. 2.

Holotype:—Cat. No. 29/2 A. C., on red sandstone from Portland, Conn. and the plesiotype, No. 3511 Y. P. M., from Turners Falls, Mass.

Specific Characters:—Manus: Four impressions made by the toes rarely exceed 12 mm. in diameter and have a circular or somewhat elliptical outline. The same is true of the ball imprint. Total length of the hand, about 50 mm.; its breadth, 40 mm.

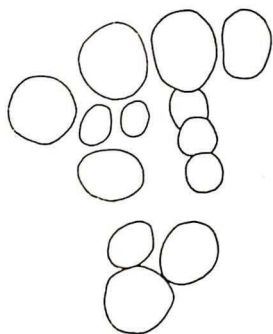


FIGURE 156.

Cunichnoides cf. *C. marsupialoideus* Hitchcock, original from Cat. No. 3511 Y. P. M. one-half natural size.

Pes: Resembling the hand, but somewhat larger, the impressions of the digits 15 mm. in diameter. Length of the foot, about 37 mm.; its breadth, 58 mm.

Localities:—Portland, Conn., and Turners Falls, Mass.

Geological Distribution:—Upper (Portland) series.

Discussion:—There is in the Yale collection another specimen of *Cunichnoides*, Cat. No. 3511 Y. P. M., a single footprint associated with two trackways of *Batrachopus deweyi*. This specimen, however, came from Turners Falls, Mass., where it was collected in 1889. The Yale specimen is highly suggestive of the type, even to the dimensions of the digital impressions. It does not, however, aid in determining what manner of creature made the *Cunichnoides* tracks although there are dermal granulations in the three forward depressions, thus proving the track to be of vertebrate origin.

Stratigraphically the two localities, Turners Falls and Portland, are contemporaneous, geographically they are about seventy miles apart!

Hitchcock considered these tracks to be of mammalian origin, low in the class and therefore, according to his belief, marsupials.

Because of the dog-like appearance of the footprints Hitchcock called them those of a cunoid or dog-like marsupial; hence the name *Cunichnoides marsupialoideus*; and there the matter rests after 95 years since the publication of the original description of these curious phenomena.

Genus *Helcura* E. Hitchcock

E. Hitchcock 1848, p. 244; 1858, p. 140.

Lull 1904A, p. 530; 1915, p. 249.

Generic Characters:—"Quadrupedal; tail and toes often dragging on the ground" (Hitchcock). Broad body trace.

Discussion:—These traces give absolutely no data concerning the form and structure of the feet. Hitchcock compares the markings to those left by living land tortoises and hence classes them provisionally with the Chelonia.

Helcura anguinea E. Hitchcock

E. Hitchcock 1858, p. 141, pl. 36, fig. 9.

Lull 1904A, p. 530; 1915, p. 249.

Holotype:—Cat. No. 40/8 A. C., on gray shale, from Turners Falls, Mass.

Specific Characters:—Length of stride of same foot, 125 to 150 mm. Width of trackway, 75 mm.

Locality:—North bank below Turners Falls, Mass.

***Helcura littoralis* E. Hitchcock**

E. Hitchcock 1848, p. 244, pl. 15, fig. 1; pl. 23, fig. 3.

Helcura caudata E. Hitchcock 1858, p. 140, pl. 37, fig. 3; pl. 40, fig. 1.

Lull 1904A, p. 531; 1915, p. 250.

Holotype:—Cat. No. 26/10 A. C., from Turners Falls, Mass.

Specific Characters:—Length of stride, 150 mm. Width of trackway, 125 mm.

***Helcura surgens* E. Hitchcock**

E. Hitchcock 1858, p. 141, pl. 36, fig. 10.

Lull 1904A, p. 531; 1915, p. 250.

Holotype:—Cat. No. 19/8 A. C., from Turners Falls, Mass. Not otherwise recorded.

Specific Characters:—Width of trackway, 125 to 150 mm. No tail trace or footprints.

PART III

VISUALIZING THE TRACKMAKERS¹

The trackways offer to one of imagination a new picture of the terrestrial footprint makers of the Connecticut Trias, for the character of the feet, the gait whether bipedal or quadrupedal, and the width of body and approximate length of limb are revealed. This is the factual evidence. The writer has modelled the feet, which are of course based upon this factual evidence; for the rest of the animal, known skeletons of Triassic forms, not necessarily from the Connecticut valley, have been used to establish the general proportions and character of the maker of the footprints, although in the final clothing of the skeleton with flesh one's imagination, based upon some knowledge of existing reptiles and amphibia, has been allowed to influence the result. The final result is of course incapable of proof, but in the absence of factual evidence destroyed some 160 million years ago it is also incapable of disproof. Thus these restorations are offered for what they are worth. But they do show a number of interesting things, among others the small size and considerable variety of most of the denizens of that remote time, although a few of them reached an overall length of twenty or more feet.

The restorations, which were modelled by the author, were photographed by Percy Morris and then drawn by Shirley Glaser, and include the following:

¹In 1948 an anonymous statement appeared in *The Earth Science Digest* (vol. 3, no. 4, pp. 12-13) entitled "Scientist 'Builds' Animals to fit puzzling Fossil Tracks." This evidently referred to the paper by Frank E. Peabody published in 1948 in which he analyzes the fossil trails and in a few instances illustrates the feet of *Cheirotherium* as restored from the tracks, but goes no further in the restoration of the entire animal. The anonymous article was unknown to the present author at the time the portion of this Bulletin on the visualizing of the trackmakers was written, although Peabody's original paper was known and appreciated. If this constitutes a previous exposition of the idea it may be acknowledged as such, but the detailed visualizing of the trackmakers is the author's own.

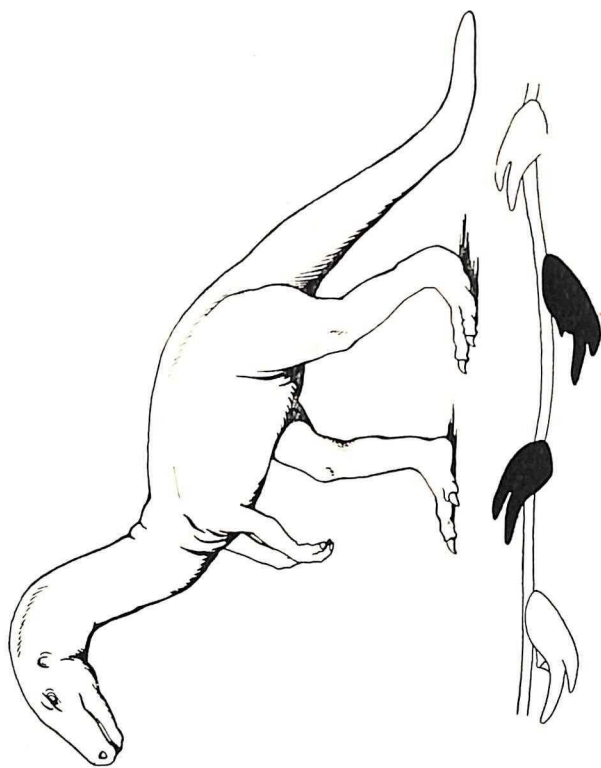


FIGURE 157.

Selenichnus falcatus E. Hitchcock. Based upon trackway by Lull. A small caelurosaurian dinosaur. Proportions suggested by *Saltopus* after V. Huene. One-fourth natural size.

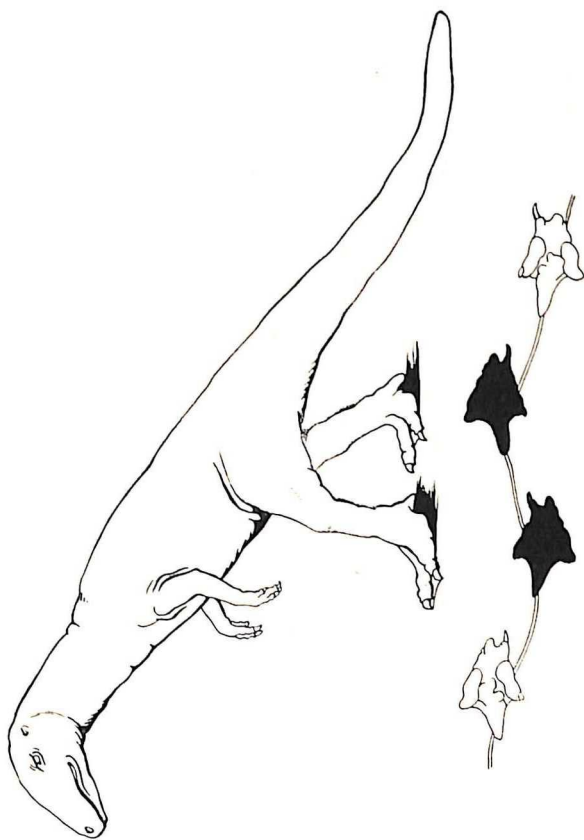


FIGURE 158.

Hyphypus fieldi E. Hitchcock. Based upon trackway by Lull. A small coelurosaurian dinosaur, possibly web-footed. Proportions suggested by the thecodont *Saltoposuchus* after V. Huene. One-eighth natural size.



FIGURE 159.

Gigandipus caudatus E. Hitchcock. A carnosaurian dinosaur based upon the trackway after Hitchcock. Proportions modified from *Teratosauros* after V. Hucne. One-fourtieth natural size. One of the largest of the Connecticut valley forms with a possible length of twenty or more feet.

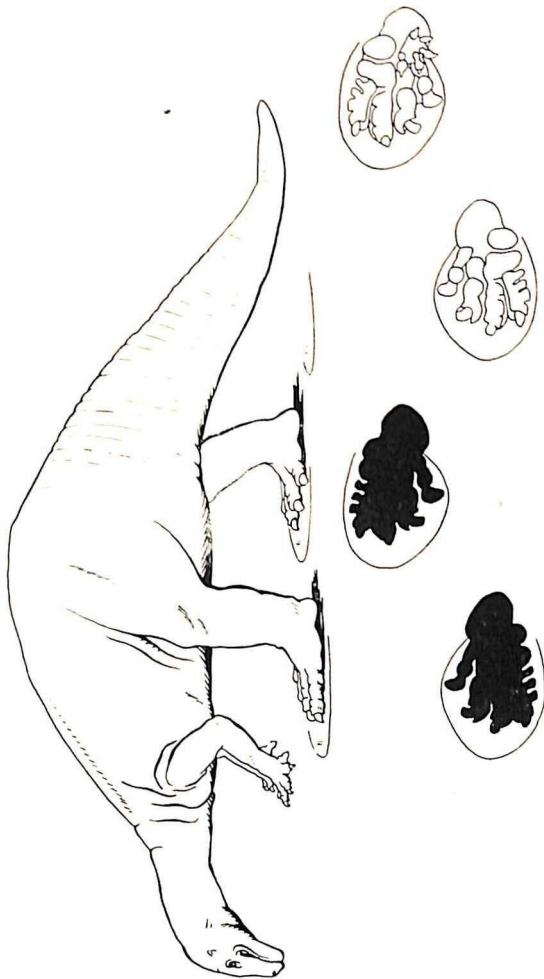


FIGURE 160.

Ootzorum moodii E. Hitchcock. Based on the trackway by Hitchcock. A large prosauropod dinosaur. Suggested by *Plateosaurus* except for the fore feet which are less prehensile. Possibly of plant feeding habits. One thirty-second natural size. Overall length of animal about twenty feet. The so called flange or web described by Hitchcock is interpreted as a wave of mud displaced by the animal's weight.

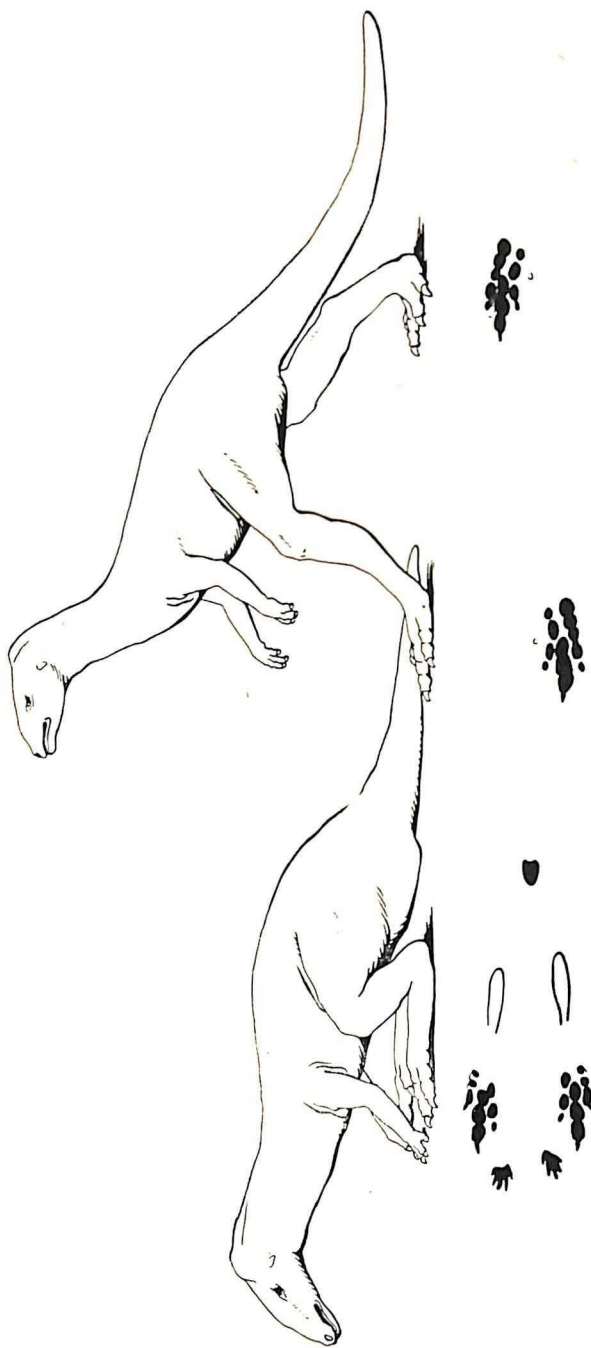


FIGURE 161.

Sauropus barrattii (E. Hitchcock). Based upon the trackway after Hitchcock. An ornithopod dinosaur. Proportions suggested by those of *Hypsilophodon* except for the elongation of the tarsus. One-sixteenth natural size. The interpretation of this animal as an Ornithischian is largely influenced by the small *Camptosaurus*-like hands which are devoid of grasping claws. Osseous remains of Ornithischia are as yet unknown from the Triassic. Interpreted as a plant-feeding animal with a length of about six feet.

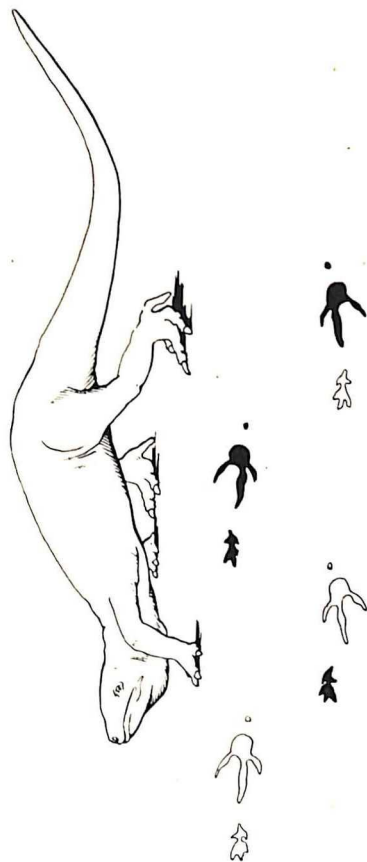


FIGURE 162.

Ammopus marshi Lull. Based upon the trackway after Lull. A small quadrupedal form of unknown affinity. Restored as somewhat lizard-like in appearance, one-fourth natural size.

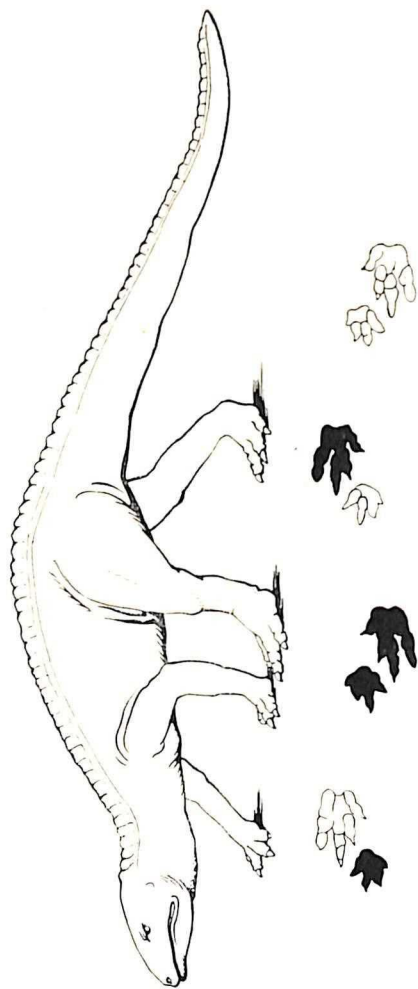


FIGURE 163.

Batrachopus deweyi (E. Hitchcock). A quadrupedal reptile probably allied to *Stegomastuchus*.
A thecodont reptile of the suborder Pseudosuchia, one-fourth natural size.



FIGURE 164.
Cheirotheroides pilulatus E. Hitchcock. A quadrupedal pseudosuchian reptile allied to
Stegomosuchus. One-half natural size.



FIGURE 165.
Arachnichnus dehiscens E. Hitchcock. Quadrupedal reptile based on the
trackway by Lull, one-half natural size.



FIGURE 166.

Comptichnus obesus E. Hitchcock. A small quadrupedal reptile, based upon the trackway by Lull. The bulk of the weight is borne on the stubby toed feet, only the tips of the digits of the small hand impressing as though the creature were rising to a bipedal gait. In many instances the hand does not impress at all. One-half natural size.

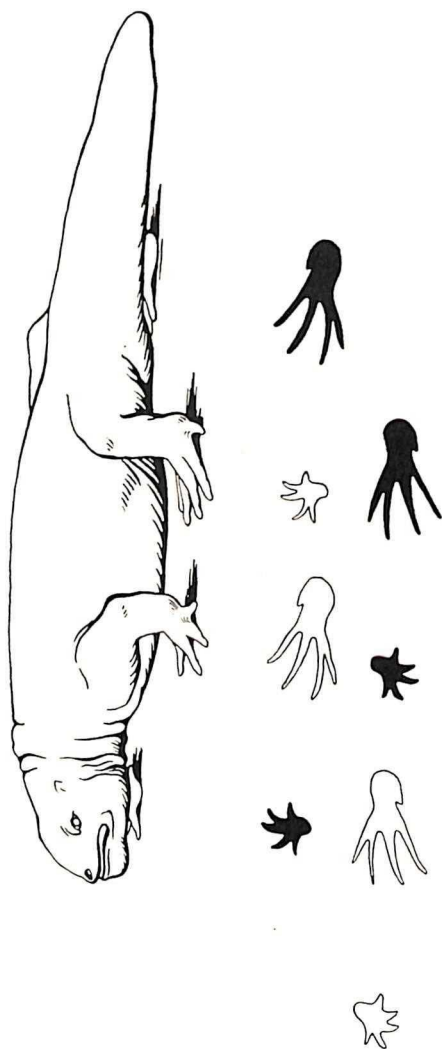


FIGURE 167.
Sustenodactylus curvatus (E. Hitchcock). A primitive quadrupedal reptile. Restoration suggested by the contemporaneous *Hypsognathus* of New Jersey. Trackway by Lull, one-half natural size.

NEW APPROACH TO THE STUDY OF FOSSIL FOOTPRINTS NUMERICAL DIAGRAMS

These are applicable largely to what Hitchcock called the pachydactylous or thick-toed tracks which are largely of dinosaurian origin.

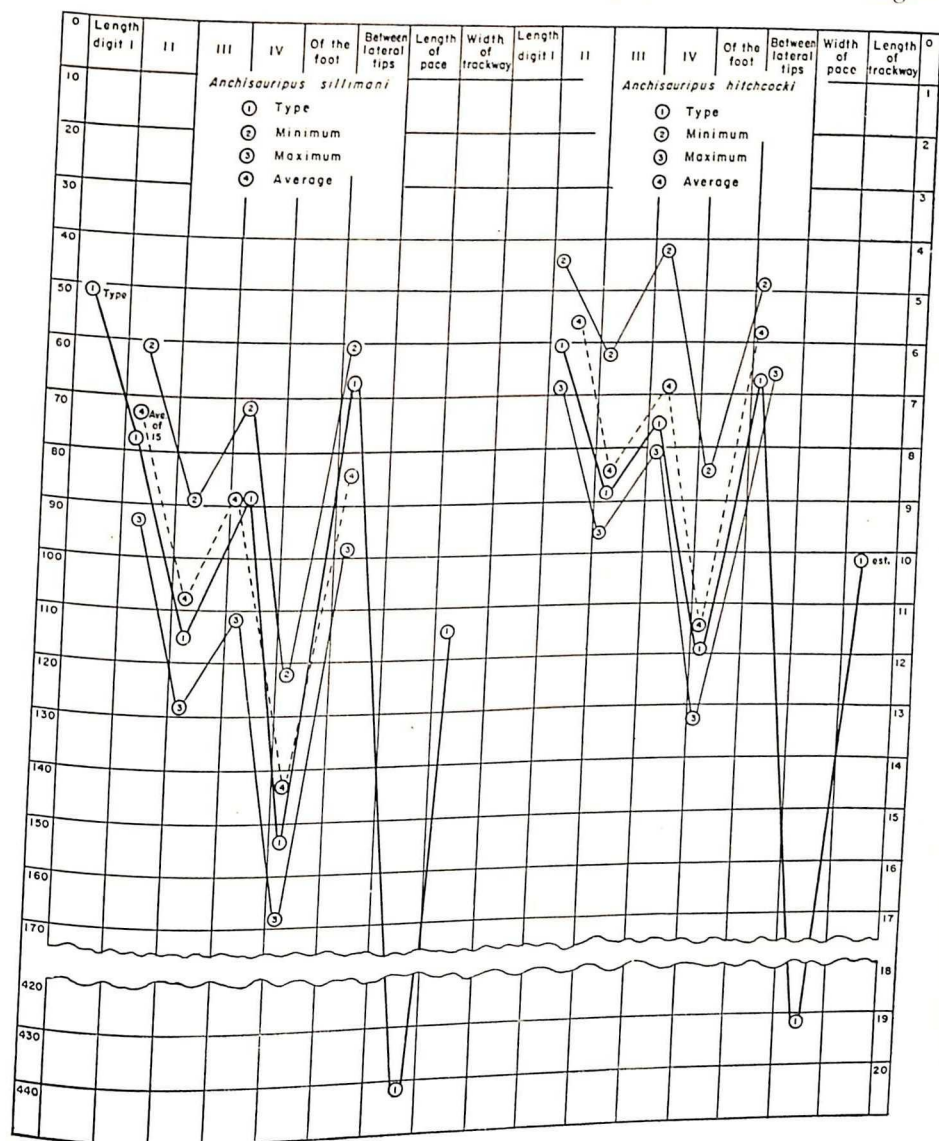


FIGURE 168.

Numerical diagrams of *Anchisauripus sillimani* and *hitchcocki*.
One-third natural size.

The squares shown are centimeters, the millimeters having been eliminated.

In these numerical diagrams the first approach is based upon numerical proportions which have been plotted on engineering paper divided into spaces which represent millimeters. These points have been connected by lines which form a visible diagram of the digital and other proportions of the footprint. They show the extent of variation within a species; the dimensions of the type specimen, also the maximum and minimum dimensions attributed to it, and the average measurements of all.

The diagram pictures the actual and relative lengths of the foot, the distance between the tips of the claws of the lateral digits, II and IV, the length of the pace, and the width of the trackway.

Many specimens in the Amherst and Yale collections have been measured and diagrammed but only two, both of the genus *Anchisauripus*, will be shown as they serve to illustrate the method and results.

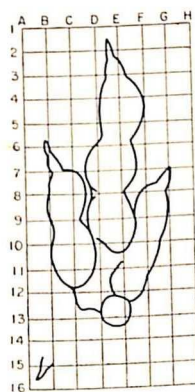
Thus the diagrams (Fig. 168) show the degree of variation within a species and that of relationship of forms assumed to be of different species. Actual differences may be due to age or other variations shown by the animal which made the track. Apparent differences may be due to the pace of the animal and the character and degree of moisture and subsequent alteration of the sediment upon which the animal walked. In the case of counterpart specimens, one is the actual track of the animal impressed upon the sediment and the other the natural cast of the track made by subsequent material laid down upon the impression, the intaglio or depressed track and the cameo or relief track, which may show variation of equivalent dimensions between the two. A swift pace often caused a deeper imprint of the front end of the foot and a deliberate walk emphasizes the rear so that subsequent impressions of the same foot may show differences which are due to posture alone.

Figure 168 shows the variation and similarity between two closely related species, *Anchisauripus sillimani*, the genotype, and *A. hitchcocki*.

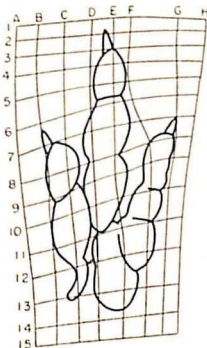
CARTESIAN DIAGRAMS

The second new approach to the study of the footprints makes use of the Cartesian diagrams used to so great an effect by Sir D'Arcy Thompson in his "Growth and Form", with this difference, that Sir D'Arcy's diagrams may represent a phylogenetic line as time goes on, well illustrated by the skulls of horses from *Eohippus* to *Equus*, while in the footprints of the Connecticut Triassic the time element does not enter into the picture, for the ichnites studied are all either approximately contemporaneous or their precise stratigraphical sequence has not been determined. Thus the evolutionary changes in a phylogenetic series cannot be shown.

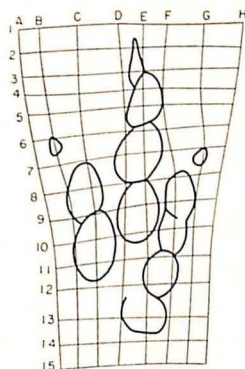
The author has chosen five well known genera of dinosaurian footprints, *Anchisauripus*, *Grallator*, *Eubrontes*, *Gigandipus*, and *Anomæpus*, with from one to six species in each for comparison.



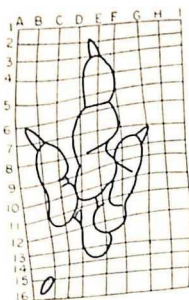
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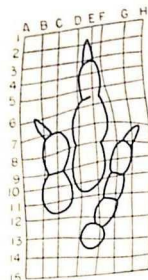
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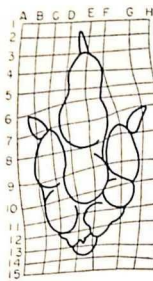
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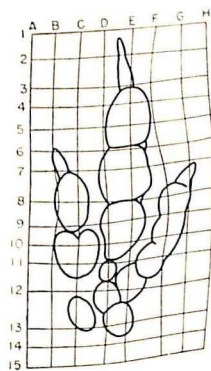
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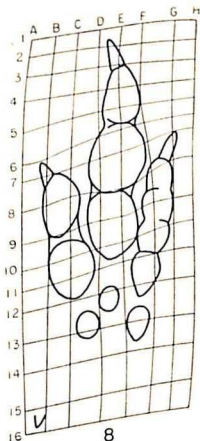
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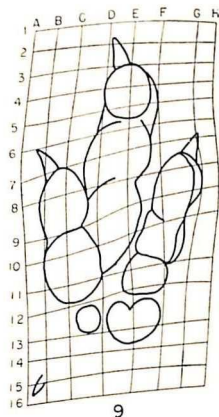
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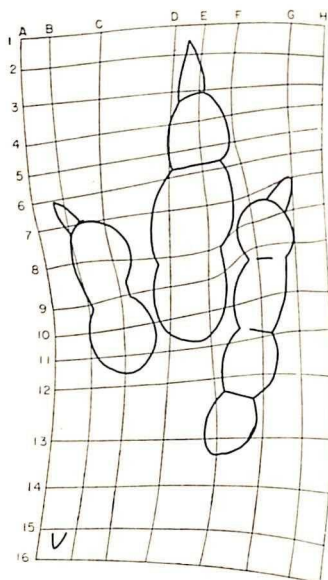


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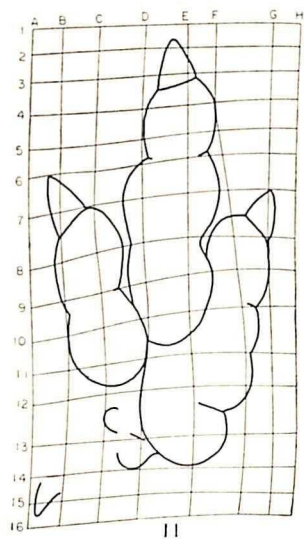


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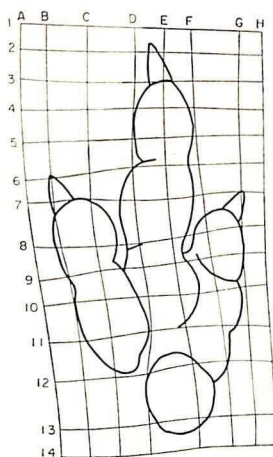
PLATE IX.—Cartesian diagrams of *Anchisauripus*, Figs. 1 (basic diagram) 2, 3, 7, *A. sillimani*, Figs. 4, 5, 6, *A. hitchcocki*, Fig. 8, *A. parallelus*, Fig. 9, *A. tuberosus*. One-fourth natural size.



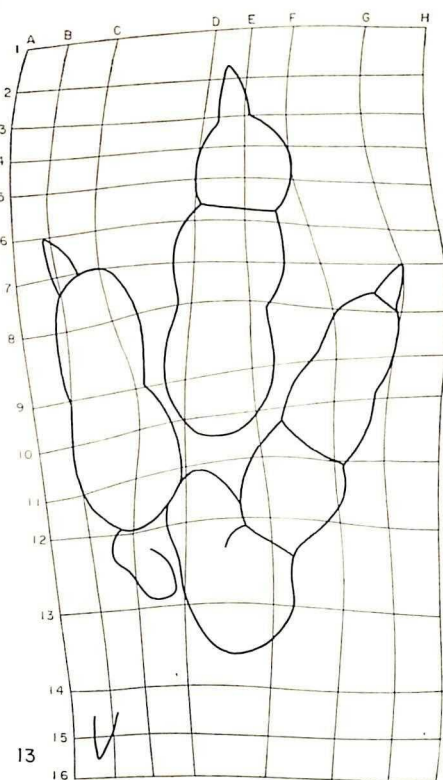
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PLATE X.—Cartesian diagrams of *Anchisauripus*. Figs. 10, 11, 12, *A. exsertus*; Fig. 13, *A. minusculus*. One-fourth natural size.

Genus *Anchisauripus*

Plates IX, X

The basic diagram of *Anchisauripus* has been made by drawing a rectangular grid with the parallel coordinates both vertical and horizontal spaced one-half inch apart. Upon this grid a full-size outline of the footprint of the genotype, *Anchisauripus sillimani*, has been drawn. This thus becomes the basis of comparison of each of the several species of the genus.

The points of intersection of the coordinates with the track outline having been determined and transferred to the track outline of several examples of this and the other species, become the points through which the corresponding coordinates must be drawn. They are seen to be no longer straight or parallel with rectangular intersections but are distorted from the basic grid in varying degree. Approximation to the original grid would show a close degree of relationship—departure therefrom, the variations either of size, proportions, and so on, mentioned above.

Figure 1. The basic diagram of *Anchisauripus* drawn from the type specimen of *A. sillimani*, Cat. No. 9/14 A. C., the "Middletown slab."

In this and the other diagrams the horizontal coordinates are designated by figures 1 to 16, the vertical by letters A to H, for convenience of reference.

Figure 2. *A. sillimani*, specimen No. 4/1 A. C. from Moody's Corner, Mass. The grid shows a distinct forward bending of the horizontal coordinates toward the outer side of the foot, stressing the greater relative length of the fourth digit and a larger heel pad behind it. The vertical coordinates tend to flare apart toward the front of the foot, except coordinate F which curves sharply toward digit III, thus widening the space between F and G at their anterior end. This may be due in part to the apparent small size of pad III-1 and to a somewhat greater divarication of digit IV. Possibly the attitude of the foot has influenced this, less weight being borne in front and more toward the heel.

Figure 3. *A. sillimani*, based upon specimen No. 32/8 A. C. from Turners Falls, Mass., also identified as *A. sillimani*. In this the horizontal coordinates depart but little from those of figure 1 except that a slight forward pushing toward the outer side of the foot shows a somewhat longer digit IV. The vertical coordinates, however, differ markedly in that they also flare apart toward the front of the foot with the exception of coordinates E and F. This is due to the greater divarication of the lateral toes.

Figure 4. *Anchisauripus hitchcocki*, from the holotype, Cat. No. 56/1 A. C., from the Lily Pond, Gill, Mass.

This form differs from *A. sillimani* chiefly by its smaller size. The vertical coordinates are but slightly curved, the horizontal ones much more so, especially in being convex forward in the outer portion of the track. This curvature may be due in part to the slow pace

of the animal which would tend to increase the weight borne on the rear portion of the track. Unfortunately the type specimen is an isolated track thus giving no indication of the length of pace, which would be corroborative evidence. The distinction of size may be due to individual age. This factor is more clearly shown in figure 5.

Figure 5. Cat. No. 9/14 A.C. This is the famous "Middletown slab" which also bears the type specimen of *A. sillimani* shown in the basic diagram, figure 1. There is a slight curvature in the vertical coordinates toward the outer side of the foot which may again be due to a difference in gait, less weight being impressed toward the anterior end of the track, thus making the pad III-1 lighter. The horizontal coordinates show a forward convexity due again to less weight borne on the digits.

The great similarity between the tracks (figures 1 and 5) and their association on the same slab, cast doubt upon their distinction other than that of individual age of the same species of dinosaur and therefore upon the validity of *hitchcocki* as a separate species.

Figure 6. Also attributed to *Anchisauripus hitchcocki*, based upon Cat. No. 47/32 A.C., the locality of which is not recorded. Aside from its smaller size the whole character of the track is very distinctive, especially in the greater relative size of phalangeal pads III 2 and 3, and IV 1. The specimen seems to be that of a proportionately heavier animal than the basic *A. sillimani* (figure 1), but this may be due in part to the condition and character of the sediment, giving a marked degree of specific distinction other than the over-all length. The outward convexity of the vertical coordinates and the forward convexity of the horizontal ones bear this out.

Figure 7. Cat. No. 26/16 A.C., from Moody's Corner, Mass., attributed to *A. sillimani*. Shows a marked similarity to the genotype in the comparatively rectilinear horizontal coordinates, but differs in the outward convexity of the vertical coordinates, but differs in with a return toward the axis of the track farther forward, especially shown in coordinate F. The complexity of the sole or heel pads is much greater than in the type, conforming to the specific description of the species *A. parallelus* in which the three sole pads are stressed as distinctive.

Figure 8. *Anchisauripus parallelus*, holotype, Cat. No. 54/8 A.C., from Field's Orchard, Gill, Mass. resembles figure 7 in the presence of the three heel pads but differs from it in the slightly larger size and in the relatively greater length of the second phalangeal pad in digit III, as shown by a forward curve of horizontal coordinates 6 and 7, and in the greater length of digit IV. The vertical coordinates are straighter and more nearly parallel than in figure 7, showing the origin of the specific name, *parallelus*.

The general resemblance between figures 7 and 8, however, is such as to show close relationship if not specific identity.

Figure 9. *Anchisauripus tuberosus*, holotype, Cat. No. 31/73 A. C., from Turners Falls, Mass. The Cartesian grid shows little irregularity of the vertical coordinates, but a bending forward toward the outer side of the foot for the fourth and second claw tips are about on a line, which brings coordinate 7 forward on the right as compared with its straight character in *A. sillimani*.

Under the later specific name *validus* are catalogued many specimens in the Amherst collection. But the distinction between these and *exsertus* is not always clear, as there is considerable variation among each of them.

Figure 10. Type specimen of *Anchisauripus exsertus*, Cat. No. 16/6 A. C., from Smith's Ferry, Mass. Here again there is the distortion of the horizontal coordinates, especially numbers 7 to 9, for the fourth digit is long enough to bring the tip of the claw opposite to that of digit II and not behind it as in the basic *A. sillimani*. There is also some distortion of the vertical coordinates because of the indifferance in divarication of digits II and III, inward, which increases the distance between coordinates C and D toward the anterior end of the foot.

The greater protrusion of the third digit, from which Hitchcock took the name *exsertus*, is not in evidence from the Cartesian diagram.

Figure 11. *Anchisauripus exsertus*, from the specimen No. 54/1 A. C., which the writer used instead of the type for illustration (Lull 1915, fig. 4), shows little distortion of the coordinates except a forward convexity from horizontal coordinates 7 to 10 due to the greater protrusion of digit III. There is an apparent widening between 12 and 13 and the hallux draw which is crossed by 15 is nearer the heel pad than in the type. The vertical coordinates show a very slight reversed curvature, especially B, C and F as compared with those of the types, but the resemblance is of kind rather than degree of curvature.

Figure 12. *Anchisauripus exsertus*, based upon Cat. No. 34/14 A. C., from Turners Falls, Mass., a somewhat smaller individual than the holotype. It agrees with figure 11 in having the claw of digit IV out of line with the claw tip of II so that the horizontal coordinate 7 lacks the abrupt forward curve shown in the figured specimen, figure 11.

Figure 13. *Anchisauripus minusculus*, holotype, Cat. No. 16/1 A. C., from the Lily Pond, Gill, Mass. This is a magnificent species, much the largest of the genus, but still showing *Anchisauripus* characters although as large as some forms of *Eubrontes*. The Cartesian diagram shows some distortion of the horizontal coordinates but more in the vertical ones, due largely to the greater body weight of the animal as compared with *A. sillimani*.

This species is most closely related to *A. exsertus* and such differences as they show may be due largely to greater individual age.

If the tracks are those of possible seasonal migrants from some as yet undiscovered habitat, then the difference in size could be due to at least one season's difference in age, which could readily result in the recorded increase in size from *exsertus* to *minisculus*. Compare figures 12 and 14.

Summary: *Anchisauripus sillimani* and *hitchcocki* are very closely akin—age distinction may account for much of the apparent specific distinction.

A. parallelus, holotype, figure 8, is close to figure 4 which was identified as *A. sillimani*. They both possess the three heel pads. But in figure 7 the fourth digit is not parallel as in Figure 8 and it does not extend so far forward in the latter, as shown by horizontal coordinates 7 and 8.

The figured specimen *A. exsertus*, figure 10, differs from the two other tracks assigned to this species, figures 11 and 12, by the widely offset digit II, and the hallux claw is farther to the rear as shown by horizontal coordinates 12 to 15, which are crowded together in figure 11. The species is not close to any other unless it be *tuberosus* which is similar but smaller. Compare figures 9 and 11 in which the distinction is so slight that it may be one of age only.

Anchisauripus minisculus is clearly defined because of its great size. The similarity to *exsertus*, figure 12, is again a possible age distinction and in a sufficiently large series one might find gradational forms.

The swaying forward of the horizontal coordinates toward the outer side of the foot is a characteristic of many of the specimens regardless of species, and may be due to posture.

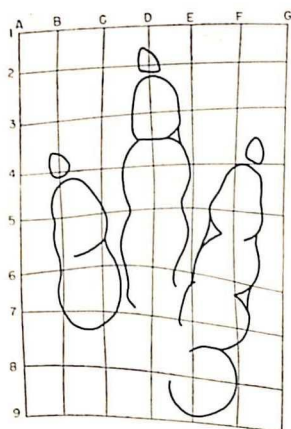
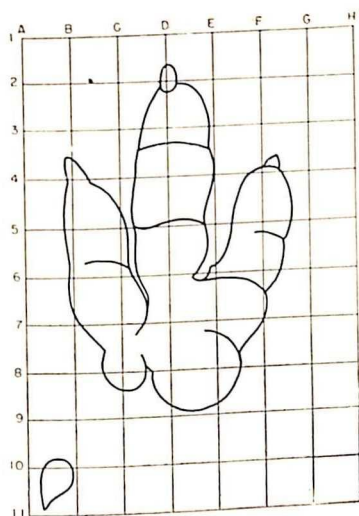
Genus *Eubrontes*

Plate XI

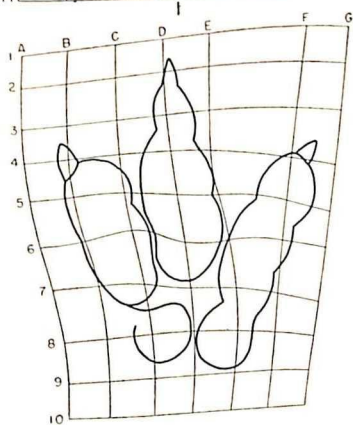
Figure 1. *Eubrontes giganteus*, genotype, Cat. No. 45/1 A. C., (plesiotype). Locality unrecorded. Basic Cartesian diagram. This is the only *Eubrontes* specimen known to the writer which shows an apparent hallux claw imprint.

Figure 2. *Eubrontes approximatus*, plesiotype, Cat. No. 32/51 A. C., from Turners Falls, Mass. The vertical coordinates are nearly straight, but the horizontal ones from No. 5 backward show the same curvature, especially No. 6. Digits more slender than in *giganteus*. Conditions of the sediment may be partly responsible for the apparent distinction between *approximatus* and *giganteus* and the track may sometimes be confused.

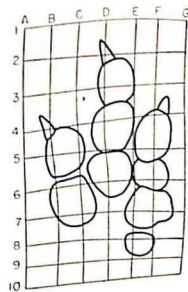
Figure 3. *Eubrontes divaricatus*, holotype, Cat. No. 58/1 A. C. Locality not recorded. Vertical coordinates E and F diverge widely toward the front of the track, stressing the divarication of digit IV. The horizontal coordinate 6 bends toward the rear where it crosses pad III-3, showing that the whole middle digit is farther to the rear



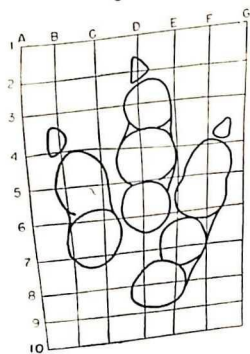
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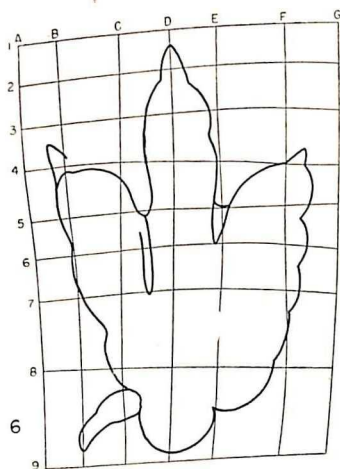


PLATE XI.—Cartesian diagrams of *Eubrontes*. Fig. 1, *E. giganteus* (basic diagram); 2, *E. approximatus*; 3, *E. divaricatus*; 4, *E. platypus*; 5, *E. tuberatus*; 6, *Gigandipus caudatus*. One-fourth natural size.

as compared with the two lateral toes. The vertical coordinates emphasize the divarication of digit IV, which is the source of the specific name. This and the relative position of digit III show a marked distinction from *giganteus* and *approximatus*.

Figure 4. *Eubrontes platypus*, holotype, Cat. No. 13/4 A. C., from Turners Falls, Mass. Proportionately broader than *giganteus* especially toward the front, as the diverging vertical coordinates show. There is no distortion of either series of coordinates. The general proportions are like those of *giganteus* although on a smaller scale. A lighter animal, possibly sometimes a juvenile of *E. giganteus*.

Figure 5. *Eubrontes tuberatus*, holotype, Cat. No. 27/17 A. C., from Turners Falls, Mass. This shows very little distortion of the diagram from that of *giganteus*. Much the smallest species of *Eubrontes*, although near *platypus* in length but more slender and compact. Fourth pad of digit IV lightly impressed, which makes it appear relatively small. Sharp claws are not characteristic of *Eubrontes* but the position of the foot in the tracks may exaggerate this.

Genus *Gigandipus*

Plate XI

Gigandipus caudatus, genotype, Cat. No. 9/9 A. C. (holotype), from the Lily Pond, Gill, Mass. The Cartesian diagram is compared with that of *Eubrontes giganteus* to show the similarity of the two species which sometimes confuses the identity of the track, for the principal distinguishing feature, that of the small hallux, is not always in evidence in the footprint. The difference in size, *Gigandipus* being the larger, may not always be apparent.

The vertical coordinates are nearly straight but the interval between coordinates E and F is greater than the others. This emphasizes the greater size of digit IV. The horizontal coordinates 7, 8, and 9 show no distortion but the interval widens greatly toward the rear of the foot, giving evidence of slow ponderous weight.

Genus *Grallator*

Plate XII

Figure 1. *Grallator cursorius*, genotype, Cat. No. 4/1 A. C., from Moody's Corner, South Hadley, Mass. Basic Cartesian diagram.

Figure 2. *Grallator tenuis*, holotype, Cat. No. 12/4, A. C., from Turners Falls, Mass. Very near to *cursorius* in size and general proportions. The horizontal coordinates are nearly straight and spaced much as in the basic grid. The vertical coordinates, especially C, are slightly curved convexly toward the outer side of the track. This is about the only distinguishing character from the genotype, and specimens referred to the two species may readily be but slightly different phases of *cursorius*.

Figure 3. *Grallator gracilis*, plesiotype, Cat. No. 23/8 A. C., from Turners Falls, Mass. A very small species. The vertical coordinates diverging toward the front of the foot. Horizontal coordinates 4 and 5 are concaved downward where they cross the middle digit. The dis-

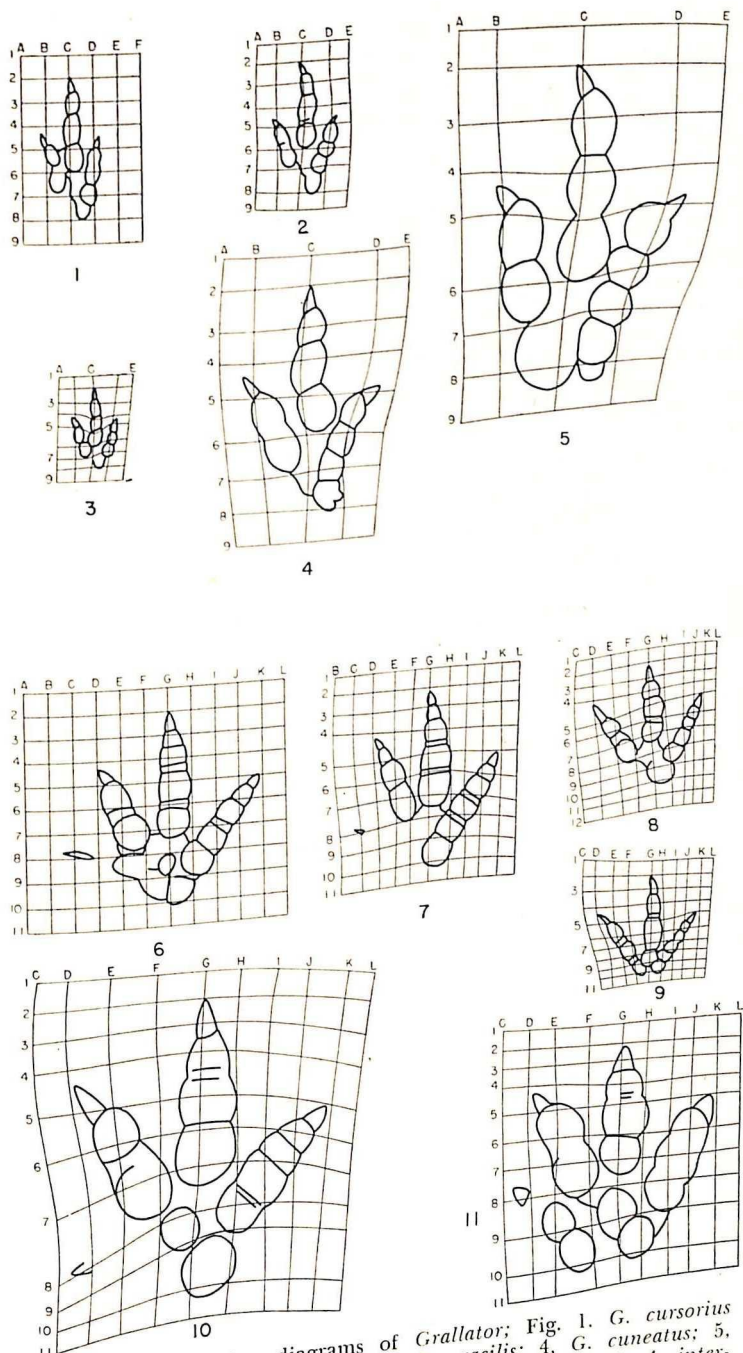


PLATE XII.—Cartesian diagrams of *Grallator*; Fig. 1. *G. cursorius* (basic diagram); 2, *G. tenuis*; 3, *G. gracilis*; 4, *G. cuneatus*; 5, *G. formosus*. Cartesian diagrams of *Anomæpus*; Fig. 6, *A. intermedius* (basic diagram); 7, *A. curvatus*; 8, *A. gracillimus*; 9, *A. minimus*; 10, *A. crassus*; 11, *A. isodactylus*. One-fourth natural size.

tortion of these coordinates is the most distinctive character. The foot is proportionately wider than *cursorius* and *tenuis*. This species is distinctive from either.

Figure 4. *Grallator cuneatus*, plesiotype, Cat. No. 17/1 A. C., from Turners Falls, Mass. This species differs markedly from the three foregoing ones, being much larger and less compact. The vertical coordinates flare apart toward the front of the foot, due to greater divarication of the digits, while the horizontal coordinates are approximately straight. The length of the claw of digit III widens the space between coordinates 2 and 3. The foot to step ratio is about the only *Grallator* character the species shows.

Figure 5. *Grallator formosus*, holotype, Cat. No. 3 A. C., from Moody's Corner, South Hadley, Mass., associated with *Otozoum*. This species departs radically from the genotype of *Grallator* in its much greater size and less compact foot. The vertical coordinates B, C, D flare apart anteriorly and D in particular is curved inward toward the rear. There is comparatively little curvature in the horizontal coordinates with the exception of 5.

This species again seems to be unrelated to the other *Grallators* and is in no sense a typical *Grallator*. It reminds one of certain *Anchisauripus tuberosus* specimens, but is less compact. The step is not extremely long as in typical *Grallators* and its generic assignment is very questionable.

Figures 1, 2, and 3 show closely related and typically *Grallator* species. Figure 4, *G. cuneatus*, shows a wide departure from the first three and figure 5, *G. formosus*, a yet wider one. Both the two last species are probably not congeneric with the first three.

Genus *Anomæpus*

Plate XII

Figure 6. *Anomæpus intermedius*, holotype, Cat. No. 48/1 A. C., from Turners Falls, Mass. Walking posture. Basic Cartesian diagram.

Figure 7. *Anomæpus curvatus*, holotype, Cat. No. 52/10 A. C., from the Lily Pond, Gill, Mass. Size about that of *A. intermedius*. Vertical coordinates nearly parallel. F and G converging slightly toward the front, G indicating the inward curvature of digit III., hence the specific name. Horizontal coordinates 5 and 6 somewhat convex forward where they cross digit III. Convexity fades toward the rear of the foot. *Anomæpus intermedius* and *curvatus* are closely related if not identical and are both very near *A. scambus*, the genotype.

Figure 8. *Anomæpus gracillimus*, plesiotype, Cat. No. 2045 Y. P. M., from the Ferry, Gill, Mass. Much smaller than *A. intermedius*. Grid somewhat distorted as compared with the basic one. Vertical coordinates farther apart toward the inner side of the foot but the interval is much narrowed between coordinates I, J, and K for digit IV is narrow with less divarication from digit III. The horizontal coordinates slant forward toward the outer side of the footprint, especially No. 5.

This species shows no close relationship toward any other except the much smaller *A. minimus*.

Figure 9. *Anomæpus minimus*, holotype, Cat. No. 55/1 A. C., from Field's Orchard, Gill, Mass. Grid distorted, especially the vertical coordinates, toward the inner side of the foot (coordinates D, E, and F). Outer ones straight. Horizontal coordinate 5 bends forward toward digit IV. Resemblance to *gracillimus* is very close except for size, which may be an age variation, *gracillimus* being the older.

Figure 10. *Anomæpus crassus*, holotype, Cat. No. 50:4:1, Rutgers Collection, from Whitehall, N. J. Also a Connecticut form. Much larger than the preceding. Vertical coordinates with little distortion except Nos. C, D, E, which bend inward due to greater divergence of digit II. Horizontal coordinate 5 curved backward at the outer end, due to shortening of digit IV, Coordinate 8 which passes through the hallux claw is curved backward sharply toward the inner side of the foot, thus influencing the coordinates on either side of it. This track is unique, resembling that of no other species.

Figure 11. *Anomæpus isodactylus*, holotype, Cat. No. 129 and its counterpart No. 142, Mt. Holyoke Collection (destroyed by fire). Vertical coordinates nearly straight, space between E, F, and G somewhat widened. Horizontal coordinates approximately straight except No. 4 which seems to sag at G, also 9 and 10, which sag toward the inner side of the foot.

The resemblance to *crassus* is greater than that to any other species except that the proximal pads of the hallux are visible and its deviation from digit II very much less than usual. The entire foot is more robust.

Bibliography

- Abel, O.**
 1926. Amerikafahrt, Die Lebenspuren in der oberen Trias des Connecticuttales, pp. 12-35, figs. 1-29.
- Barrell, J.**
 1912. Central Connecticut in the geologic past. Proc. and Coll. Wyoming Hist. and Geol. Soc. (Wilkes-barre, Pa.), XII, pp. 25-54, 5 pls. Republished with revision: Conn. Geol. and Nat. Hist. Survey, Bull. 23.
- Beasley, H. C.**
 1896. An attempt to classify the footprints from the Trias of this district. Proc. Liverpool Geol. Soc., VII, pp. 391-409, 3 pls.
 1902. The fauna indicated in the Lower Keuper sandstone of the neighbourhood of Liverpool. Trans. Liverpool Biol. Soc., XVI, pp. 3-26, 2 pls.
- Bibron, G. et Duméril, A.**
 1854. Erpétologie Générale des Reptiles. Atlas, Paris.
- Bock, W.**
 1945. A new small reptile from the Triassic of Pennsylvania. Notulæ Naturæ, no. 154, 1-8.
 1952. Triassic reptilian tracks and trends of locomotive evolution. Jour. Pal., 26, pp. 395-433, 9 pls. and 3 tab. and figs.
- Bradford, W.**
 1934. Additional Triassic dinosaur tracks from Pennsylvania. Science (N. S.), Vol. 80, pp. 73, 74.
- Camp, C. L.**
 1936. A new type of small bipedal dinosaur from the Navajo sandstone of Arizona. Univ. of Calif. Publ. Bull. Dept. Geol. Sci., 24, pp. 39-56, 8 figs., 2 pls.
- Colbert, E. H.**
 1946. Hypsognathus, A Triassic reptile from New Jersey. Bull. Am. Mus. Nat. Hist., 86, pp. 231-274, figs. 1-20, pl. 33, figs., 1, 2. Restoration.
 1947. Studies of the phytosaurs *Machæroprosopus* and *Rutiodon*. Bull. Am. Mus. Nat. Hist., 88: Article 2, pp. 57-96, 12 figs., 6 tables, 10 pls.
 1950. The beginning of the Age of Dinosaurs in northern Arizona. The Plateau, Mus. Northern Arizona, 22, no. 3, pp. 37-43, 1 fig.
- Cushman, J. A.**
 1904. A new foot-print from the Connecticut valley. Amer. Geol., XXXIII, pp. 154-156, pl. VI.

Davis, W. M.

1898. The Triassic formation of Connecticut. U. S. Geol. Surv., 18th Ann. Rept., Pt. II, pp. 9-192, pl. I-XX, figs. 1-52.

Davis, W. M., and Loper, S. W.

1891. Two belts of fossiliferous black shale in the Triassic formation of Connecticut. Geol. Soc. America Bull., II, pp. 415-430, figs. 1-3.

Eastman, C. R.

1911. Triassic fishes of Connecticut. Conn. Geol. and Nat. Hist. Surv., Bull. 18, pp. 1-75, pls. I-XI, figs. 1-8.

Emerson, B. K.

- 1898 A. Geology of old Hampshire county, Massachusetts. U. S. Geol. Surv., Mono. XXIX, pp. 1-790, pls. I-XXXV, figs. 1-48.
1898 B. Holyoke folio, Massachusetts-Connecticut. U. S. Geol. Surv., Geol. Atlas of the U. S., Folio 50.
1900. A new bivalve from the Connecticut river Trias. Amer. Jour. Sci., (4) X, p. 58, 1 fig.

Emerson, B. K., and Loomis, F. B.

1904. On *Stegomus longipes*, a new reptile from the Triassic sandstones of the Connecticut valley. Ibid., XVII, pp. 377-380, pl. XXII.

Gilmore, C. W.

1928. A new fossil reptile from the Triassic of New Jersey. Proc. U. S. Nat. Mus., LXXIII, 7, pp. 1-8, pls. I-III.

Hay, O. P.

1902. Bibliography and catalogue of the fossil Vertebrata of North America. U. S. Geol. Surv., Bull. 179, pp. 1-868.

Heilmann, G.

1926. The origin of birds, London, pp. 208, 2 pls, 149 text-figs. Résumé of archeosaurian reptile groups.

Hitchcock, C. H.

1866. Description of a new reptilian bird from the Trias of Massachusetts. Ann. Lyceum Nat. Hist., New York, VIII, pp. 301-302.
1871. [Account and complete list of the Ichnozoa of the Connecticut valley.] Walling and Gray's Official Topographical Atlas of Massachusetts, pp. XX-XXI.
1889. Recent progress in ichnology. Proc. Boston Soc. Nat. Hist., XXIV, pp. 117-127.

Hitchcock, C. H. and Grier, N. M.

1927. The Dartmouth College Ichnological Collection. Am. Midl. Nat. Vol. 10, pp. 184-197.

Hitchcock, E.

1836. Ornithichnology.—Description of the footmarks of birds, (Ornithichnites) on New Red Sandstone in Massachusetts. *Amer. Jour. Sci.*, XXIX, pp. 307-340, pl. [1], figs. 1-20, 23-24; pl. [2], figs. 21-22; pl. [3].
- 1837 A. Ornithichnites in Connecticut. *Ibid.*, XXXI, pp. 174-175.
- 1837 B. Fossil footsteps in sandstone and graywacke. *Ibid.*, XXXII, pp. 174-176.
1841. Final report on the geology of Massachusetts, Pt. III, pp. 301-714, pls. XV-LI. Amherst and Northampton.
1843. Description of five new species of fossil footmarks, from the Red Sandstone of the valley of Connecticut river. *Repts.*, 1st, 2d, and 3d Meetings, Assoc. Amer. Geologists and Naturalists, pp. 254-264, pl. XI.
1844. Report on ichnolithology, or fossil footmarks, with a description of several new species, and the coprolites of birds, from the valley of Connecticut river, and of a supposed footmark from the valley of Hudson river. *Amer. Jour. Sci.*, XLVII, pp. 292-322, pls. III, IV.
1845. An attempt to name, classify, and describe the animals that made the fossil footmarks of New England. *Proc. 6th Ann. Meeting, Assoc. Amer. Geologists and Naturalists*, New Haven, Conn., pp. 23-25.
1847. Description of two new species of fossil footmarks found in Massachusetts and Connecticut, or of the animals that made them. *Amer. Jour. Sci.*, (2) IV, pp. 46-57, figs. 1-3.
1848. An attempt to discriminate and describe the animals that made the fossil footmarks of the United States, and especially of New England. *Mem. Amer. Acad. Arts and Sci.*, (2) III, pp. 129-256, pls. 1-24.
1855. Shark remains from the coal formation of Illinois, and bones and tracks from the Connecticut river sandstone. *Amer. Jour. Sci.*, (2) XX, pp. 416-417.
1856. Description of a new and remarkable species of fossil footmarks, from the sandstone of Turner's Falls, in the Connecticut valley. *Ibid.*, XXI, pp. 97-100, 1 fig.
1858. Ichnology of New England. A report on the sandstone of the Connecticut valley, especially its fossil footmarks. Boston.
1863. New facts and conclusions respecting the fossil footmarks of the Connecticut valley. *Amer. Jour. Sci.*, (2) XXXVI, pp. 46-57.
1865. Supplement to the Ichnology of New England. Boston.

Huene, F. v.

1906. Ueber die Dinosaurier der aussereuropaeischen Trias. *Geol. u. Pal. Abhandl. (Koken)*, Neue Folge, VIII, Heft 2, pp. 1-60 (97-156), pls. 1-XVI (VIII-XXIII), figs. 1-102.

- 1907-1908. Die Dinosaurier der europaeischen Triasformation mit Berücksichtigung der aussereuropaeischen Vorkommnisse. Ibid., Supplement-Bd. 1, Lief. 1-6, pp. 1-419, pls. I-III, figs. 1-351.
1913. A new phytosaur from the Palisades near New York. Bull. Amer. Mus. Nat. Hist., XXXII, Art. XV, pp. 275-283, pls. XLIX, L, figs. 1-14.
1921. Neue Pseudosuchia und Cœlurosauria aus dem württembergischen Keuper. Acta Zoologica 2, pp. 139-403, 4 pls.
1929. Die Plateosaurer von Trossingen. Wochenschrift über die Fortschritte in Wissenschaft und Technik. Heft 44.
1932. Die fossile Reptil-ordnung Saurischia, ihre Entwicklung und Geschichte, Mono. Geol. Pal., 1st Ser. Heft 4, pp. 1-368. A modern summary of our knowledge of Saurischian dinosaurs, with special reference to Triassic forms.
1940. Saurierfährten aus dem Verrucano des Monte Pisano. Ibid. Jahr, 1940, Abt. B. Nr. 1, pp. 349-352.
- Jaeger, E.**
1948. Tracks and trailcraft. pp. VII, + 381, 203 figs.
- Jepsen, G. I.**
1948. A Triassic armored reptile from New Jersey (*Stegomus arcuatus jerseyensis* Jep). State of New Jersey, Dept. of Conservation. Misc. Geol. Pap.
- Krynine, P. D.**
1950. Petrology, stratigraphy and origin of the Triassic sedimentary rocks of Connecticut. Connecticut Geol. and Nat. Hist. Surv., Bull. No. 73.
- Kümmel, H. B.**
1898. The Newark system or red sandstone belt. New Jersey Geol. Surv., Ann. Rept. State Geologist for 1897, pp. 23-159, pls. II-IX, figs. 1-25.
- Longwell, C. R.**
1928. The Triassic of Connecticut. Am. Jour. Sci. (5), XVI, pp. 259-263.
- Longwell, C. R. and Dana, E. S.**
1932. Walks and rides in central Connecticut and Massachusetts, 200 pp. New Haven.
- Lull, R. S.**
1904 A. Fossil footprints of the Jura-Trias of North America. Mem. Boston Soc. Nat. Hist., V, pp. 461-557, pl. 72, figs. 1-34.
1904 B. Nature's hieroglyphics. Pop. Sci. Monthly, LXVI, pp. 139-149, 8 figs.

- 1904 C. Note on the probable footprints of *Stegomus longipes*. Amer. Jour. Sci., (4) XVII, pp. 381-382, 1 fig.
 1910. Dinosaurian distribution. Ibid., XXIX, pp. 1-39, figs. 1-10.
 1912. The life of the Connecticut Trias. Ibid., XXXIII, pp. 397-422, figs. 1-5.
 1915. Triassic life of the Connecticut valley. Connecticut Geol. and Nat. Hist. Surv., Bull. 24, pp. 1-285, pls. I-XII, figs. 1-126.
 - 1942 A. Triassic footprints from Argentina, Amer. Jour. Sci. 240, pp. 421-425, 2 figs., 1 pl.
 - 1942 B. Chugwater footprints from Wyoming, Ibid., 240, pp. 500-504, pl. I.
- Lyell, C.
1845. Travels in North America, 1841-42, with geological observations on the United States, Canada, and Nova Scotia, 2 vols. New York.
- Lyman, B. S.
- 1894 A. Some New Red horizons. Proc. Amer. Philos. Soc., vol. XXXIII, pp. 192-215, 2 maps. Lists of fossils found at numerous localities in the New Red of Mass., Conn., N. J., Pa., Va., and North Carolina.
- McGregor, J. H.
1906. The Phytosauria, with especial reference to *Mystriosuchus* and *Rhytidodon*. Mem. Amer. Mus. Nat. Hist., IX, Pt. II, pp. 29-101, pls. VI-XI, figs. 1-26.
- Marsh, O. C.
1885. Names of extinct reptiles. Amer. Jour. Sci., (3) XXIX, p. 169.
 1889. Notice of new American Dinosauria. Ibid., XXXVII, pp. 331-336, figs. 1-5.
 1891. Notice of new vertebrate fossils. Ibid., XLII, pp. 265-269.
 1892. Notes on Triassic Dinosauria. Ibid., XLIII, pp. 543-546, pls. XV-XVII.
 1893. Restoration of *Anchisaurus*. Ibid., XLV, pp. 169-170, pl. VI.
 - 1896 A. A new Belodont reptile (*Stegomus*) from the Connecticut river sandstone. Ibid., (4) II, pp. 59-62, pl. 1, text figs. 1-3.
 - 1896 B. The dinosaurs of North America. U. S. Geol. Surv., 16th Ann. Rept., Pt. I, pp. 133-244, pls. II-LXXXV, figs. 1-66.
- Newberry, J. S.
1888. Fossil fishes and fossil plants of the Triassic rocks of New Jersey and the Connecticut valley. U. S. Geol. Surv., Mono. XIV, pp. 1-XIV, 1-152, pls. I-XXVI.
- Peabody, F. E.
1948. Reptile and amphibian trackways from the Lower Triassic Moenkopi formation of Arizona and Utah. Univ. of Calif. Pub., Bull. Dept. Geological Sciences, 27, No. 8. pp. 295-468, pls. 23-45, 40 text-figs.

Rice, W. N., and Gregory, H. E.

1906. Manual of the geology of Connecticut. Conn. Geol. and Nat. Hist. Survey, Bull. 6, pp. 1-273, pls. 1-31, figs. 1-22.

Romer, A. S.

1945. Vertebrate paleontology, 2d ed., pp. VII + 687, 377 figs, 4 tables. Chicago.

Scudder, S. H.

1886. The oldest known insect-larva, *Mormolucoides articulatus*, from the Connecticut river rocks. Mem. Boston Soc. Nat. Hist., III, pp. 431-438, pl. 45.

Smith, N.

1820. Fossil bones found in red sand stone. Amer. Jour. Sci., II, pp. 146-147.

Sollas, W. J.

1879. On some three-toed footprints from the Triassic conglomerate of South Wales [*Brontozoum thomasi*]. Quart. Jour. Geol. Soc., London, XXXV, pp. 511-516, 1 fig.

Talbot, M.

1911. *Podokesaurus holyokensis*, a new dinosaur from the Triassic of the Connecticut valley. Amer. Jour. Sci., (4) XXXI, pp. 469-479, pl. IV, text figs. 1-6.

Thompson, D'A.

1943. On growth and form. Cambridge, Eng. New York.

Thorpe, M. R.

1929. A new Triassic fossil field. Amer. Jour. Sci. (V), 18, pp. 277-306, 9 figs. New species of ichnites from the Newark series.

Ward, L. F.

1900. Status of the Mesozoic floras of the United States. First paper: The older Mesozoic. U. S. Geol. Surv., 20th Ann. Rept., Pt. II, pp. 211-430, pls. 21-179.

Wheatley, C. M.

1861. Remarks on the Mesozoic Red Sandstone of the Atlantic slope, and notice of the discovery of a bone bed therein, at Phoenixville, Penn. Amer. Jour. Sci., (2) XXXII, pp. 41-48.

Woodworth, J. B.

1895. Three-toed dinosaur tracks in the Newark group at Avondale, N. J. Amer. Jour. Sci. (3), 50, pp. 481-482.

Zittel, K. A. v. (C. R. Eastman, translator and editor).

1902. Text-book of Palæontology, Vol. II. London and New York.

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of Connecticut

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